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TOWARD THE ULTIMATE GOAL

Translated from Metallurg, No. 12,
p. 1, December, 1961

The end of the third year of the seven-year plan is approaching, and this year will go down in the history of our country as one of immense labor triumphs of the Soviet people.

The XXII congress of the CPSU, which adopted the new, third program of the Communist Party of the Soviet Union, marked a new bright era in the life of all humanity. "Building a communist society has become the immediate, practical undertaking of the Soviet people. The gradual metamorphosis of socialism into communism is historically ordained; it has been anticipated in all the previous development of the Soviet socialist society." Thus is it written in the new Program of the Communist Party of the Soviet Union.

A communist society has ceased to be a Utopia, a distant dream of millions of people; its horizons are already clearly visible to us, the Soviet people. "The present generation of Soviet people will live under communism", reads the program of the CPSU. The life and deeds of the Soviet people are immediate illustrations of this.

Communist labor!

These words may now be heard in plants and factories, on state farms and collective farms –in every corner of our vast country.

Soviet metallurgists march in the front ranks of the army of builders of communism. Each year they provide the Fatherland with tens of thousands of tons of high-quality metal in excess of planned production.

Our metallurgist hailed the opening day of the XXII congress of the CPSU with labor gifts. Reports of early fulfillment of duties assumed in honor of the congress flew to Moscow from all corners of the Soviet Union. The fight for communist labor developed at all metallurgical establishments of the country. Crews, shifts, units, departments, and entire plants fought for the right to wear the honored title.

A powerful material-technical foundation, the basis of which is heavy industry, is necessary for building a communist society. In 1961 went into operation the largest blast furnace in the world at the Krivorog Metallurgical Plant and the largest open-hearth furnace in the world in the MMC, a powerful 2300 mill at the Chelyabinsk Metallurgical Plant, and dozens of large-scale units in the plants and combines of the country. This means that in the near future hundreds of thousands of tons of metal will be produced to meed the demands of the national economy.

Our party has always devoted and will continue to devote major attention to the development of metallurgy. "Further rapid increase in the production of metals and fuel, which constitute the foundation of modern industry, will continue as before to be one of the most important tasks of the national economy," reads the program of the CPSU.

Soviet metallurgists are aware of the huge responsibility which the nation has laid on them in this most noble of enterprises on the earth– the building of communism.

There is no doubt that in 1962 they will exercise all their strength, knowledge, and experience to provide the Fatherland with more iron, steel, and rolled stock which will be used in the building of a new, foremost on the earth, communist society.

CHANGE OF THE PARAMETERS OF CHARGING THE BURDEN WHILE INCREASING THE GAS PRESSURE AT THE MOUTH

V. P. Tarasov

Ilyich Metallurgical Plant at Zhdanov
Translated from Metallurg, No. 12, pp. 2-4, December, 1961

In Metallurg, No. 8, 1960 appeared the article by A. N. Chechuro and I. L. Kolesnik, "Mistakes in the Regulation of Gas Flow and Distribution of Materials at the Mouth". Below appears a response to this article.

The optimum correspondence between gas flow along the periphery and at the center of the furnace and the manner of regulating it are of decisive importance for the even descent of materials, increased productivity, and decreased fuel consumption; therefore, the article by A. N. Chechuro and I. L. Kolesnik is of definite interest.

A redistribution of gas flow takes place when the gas pressure at the mouth of the blast-furnace is increased. The technical-economic indices of smelting then depend basically on the opportune change in the technological regime, especially the parameters of charging the burden materials.

It is known that increasing the gas pressure at the mouth sharply reduces the pressure drop between the zone of the tuyeres and the mouth, increases the angle of repose of the materials charged into the furnace, and leads to peripheral gas flow.

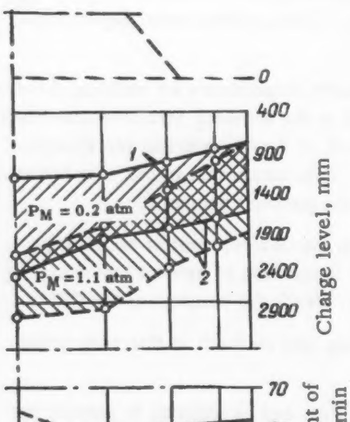


Fig. 1. Character of the cone and rate of descent of the burden with normal (solid lines) and increased (broken lines) gas pressure at the mouth: 1) after dumping the charge; 2) after a pause.

In Figure 1 are shown some profiles of materials and the manner of their descent along a radius of the mouth under normal and increased top pressure in one of the blast-furnaces of the Ilyich Plant.

It is evident from Figure 1 that under normal pressure the depth of the cone is 400-500 mm, and under increased gas pressure – 1300-1400 mm.

The rate of descent of the burden on the periphery increased from 85 mm/min under normal pressure to 125 mm/min under increased pressure. The rate of descent of the burden at the center of the furnace decreased correspondingly from 130 to 80 mm/min.

With a deep cone, the materials first charged will partially slip and slide toward the center of the furnace as a result of "squeezing-out" (Fig. 2) of the materials first falling onto the surface of the burden by the following portions of the charge.

Thus, the lower skip-loads in the large bell fall toward the center, and the following loads fall toward the periphery of the furnace. Such a distribution of materials at the mouth is directly opposed to commonly accepted ideas. In addition, it is to be noted that shifting of the burden is caused more by squeezing than by sliding, and ore squeezes out coke more easily than vice versa.

Neglecting other factors, the profile of the cone before subsequent loads are dumped has a large influence on the distribution of materials along a radius of the blast-furnace. The relief of the surface of the burden depends primarily on the rate of descent of the charge. All blast-furnace operators consider it necessary to work with a moderately devel-

oped gas flow on the periphery (this is practice everywhere). In this case when materials are charged according to the system O-C, the larger part of the ore falls toward the walls of the furnace; when loading in the reverse order C-O, on the other hand, the larger part of the coke falls on the periphery.

When blast-furnaces are operated with normal gas pressure at the mouth, the depth of the cone does not attain the value at which conditions for the redistribution of materials according to the scheme shown in Figure 2 are created even with central flow, due to the shallowness of the cone which exists before dumping the successive charges. Therefore, when operating at normal gas pressure, blast-furnace operators have not had to deal with such cases as described by A. N. Chechuro and I. L. Kolesnik, where the order of charging materials influences gas flow in a manner directly opposed to the generally known situation.

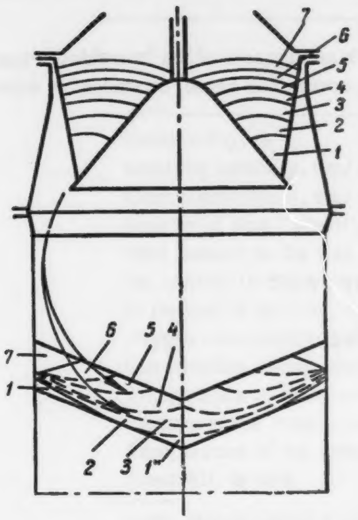


Fig. 2. The distribution of charge from 7 skip-loads at the mouth. Figures denote members of skips.

As was noted above, when the blast-furnaces are caused to operate with high gas pressure at the mouth, the angle of repose of the materials sharply increases. Together with this, as a result of the decrease in velocity of the blast and the falling of the larger part of the ore (compared with operating conditions at normal pressure) toward the center of the furnace, the gas flow becomes more peripheral, and the rate of descent of the burden increases on the periphery. For this reason, before dumping successive charges the cone does not attain the depth at which "squeezing-out" of the first loaded materials of the charge occurs.

Thus, the usual methods of regulating the distribution of gas flow along a radius of the furnace remain effective even with increased gas pressure.

When blast-furnaces are operated with higher gas pressure at the mouth, it is usually necessary to decrease the peripheral gas flow; in this case, the measures employed by blast-furnace operators in analogous situations when operating at normal pressure prove fully effective.

In order to eliminate peripheral gas flow when the gas pressure at the mouth of the blast-furnaces of the Ilyich Plant was increased, the weight of the coke charge was considerably reduced, the weight of the forward charges of the load was increased, and the burden level was lowered. In all cases this provided good results in smoothing out the gas flow and optimum technical-economic indices. It is very important that these measures be taken as soon as the gas pressure is raised without waiting for peripheral flow to develop.

If a blast-furnace with central flow is changed to operate at increased pressure, or especially from increased to high pressure, conditions many be created such that due to the great depth of the cone of materials before dumping the charge, while loading with ore first the ore will be squeezed toward the center, and when loading with coke first the coke will fall not on the periphery, but toward the axis of the furnace. Therefore, when several furnaces at the Dzerzhinsk Plant (formerly having central flow) were operated with a gas pressure at the mouth of 1.2 atm under a charging system C-O-O-C, ore (agglomerate) made its way to the periphery due to squeezing of the first skip-load of coke toward the center, and the temperature below the guard plates dropped. Thereafter, the charging system C-C-O-O was used to smooth out the gas flow. As a result of this, the periphery became still more loaded with ore, since coke was squeezed away from it. The temperature below the guard rings rose to normal only after changing to load-ore first. All this does not contradict the generally accepted ideas of the influence of the system of charging materials on the distribution of gas flow, but rather confirms them if the depth of the cone is taken into account.

Even A. N. Chechuro and I. L. Kolesnik came to such a conclusion, stressing in their conclusions that "when changing the system of charging, special attention must be given to the degree of development of central gas flow and the depth of the cone of materials at the mouth." Therefore, their assertion that "the lowest temperature of peripheral cases is where the flow of gases and materials reaches maximum intensity," i.e. in case of peripheral gas flow, is completely incomprehensible. Everyone knows that the temperature of the gas in this case rises and does not drop, although there takes place an intense transfer of heat from the gas to the descending materials encountered.

A high temperature in a region of slow and obstructed burden descent can occur only if a channel forms in this zone, which might not be discovered by the personnel tending the furnace.

One can also not agree with A. N. Chechuro and I. L. Kolesnik on the problem of the distribution of ore mounds around the mouth. In order to eliminate channels, mounds of ore should be heaped in high temperature zones of the mouth, and mounds of coke – in low temperature zones. It is evident that the mounds which the revolving distributor feeds to the cone of the small bell are weakly expressed. Moreover, the position of the mound in the cone of the small bell is not constant for the same station and depends on a whole series of changeable factors (the physical composition of the burden materials, the angle of inclination of the skip, etc.). Therefore, regulation of gas flow around the mouth with this distributor is very difficult.

In the case considered by A. N. Chechuro and I. L. Kolesnik, the depth of the cone of materials had an additional influence on the radial distribution of ore and coke.

From all that has been said it is clear that the case of elimination of a channel described in the article is not typical and cannot be recommended for all furnaces.

Unfortunately, the article gives very little data on the operation of the blast-furnaces of the Dzerzhinsk Plant before and after loading them in "reversed" order. Therefore, this interesting occurrence cannot be studied in more detail.

SMELTING FERROMANGANESE AT THE PLANT "ZAPOROZHSTAL'"

I. D. Balon, V. I. Litvinenko, T. A. Tuluevskaya, and N. T. Romanenko

Ukrainian Institute of Metals, Plant "Zaporozhstal'"
Translated from Metallurgy, No. 12,
pp. 4-6, December, 1961

In March 1960 one of the blast-furnaces at the plant "Zaporozhstal'" underwent an intermediate overhaul, during which time it was partially reconstructed with the intention of its subsequent conversion to the smelting of ferromanganese.

The burden consisted of 60% Nikopol' manganese ore of grade I and 40% agglomerate obtained from grade II ore.

The ores arrive at the ore yard irregularly, and their neutralization could not be arranged; therefore, the chemical composition of the burden was not constant in either manganese or silica. The average content of manganese in the ore burden was 40-41%. Ordinary and dolomitic limestone was used as flux in the ratio 1:1 which provided a 6-7% MgO content in the slag. The ash content of the coke was 9.5-10% with 1.7-2% sulfur. The basicity of the slag $CaO:SiO_2$ was 1.12-1.29; $(CaO + MgO):SiO_2$ was 1.32-1.47. The manganous oxide content fluctuated from 15.7 to 11.5%.

Ferromanganese was smelted using a blast enriched in oxygen. The fundamental difficulty in smelting ferromanganese in large blast-furnaces is frequent clogging of the central part of the hearth, which leads to intense burning of the tuyeres, an increased number of standstills, and, as a result, to production losses. An increased quantity of fines in the ore component of the burden, high slag output, and an extended zone of slag formation are factors making difficult the feeding of a sufficient quantity of blast into the furnace to relieve the central part.

Repeated attempts to increase the quantity of blast occasioned increased output of blast-furnace dust and disruption of furnace operation. Increasing the gas pressure at the mouth without increasing the quantity of blast correspondingly led to the development of peripheral flow and a decrease in the rate of movement of gases in the center; this did not contribute to the activity of the center.

As a means of fighting clogging, the hearth was periodically flushed (every 35-40 days) by switching the furnace to the smelting of another type of iron (specular iron or iron for steel manufacture). However, this did not eliminate the basic causes leading to clogging of the hearth, and it forced work on the activation of the center of the furnace.

In February 1961 were installed 6 special long tuyeres (at the junction of the coolers of the tuyere zone and the bosh) at an angle of 5° to the horizontal. They were located 717 mm above the axis of the main row of tuyeres. They protruded 1200 mm into the furnace, and the diameter of the exit aperture was 25 mm.

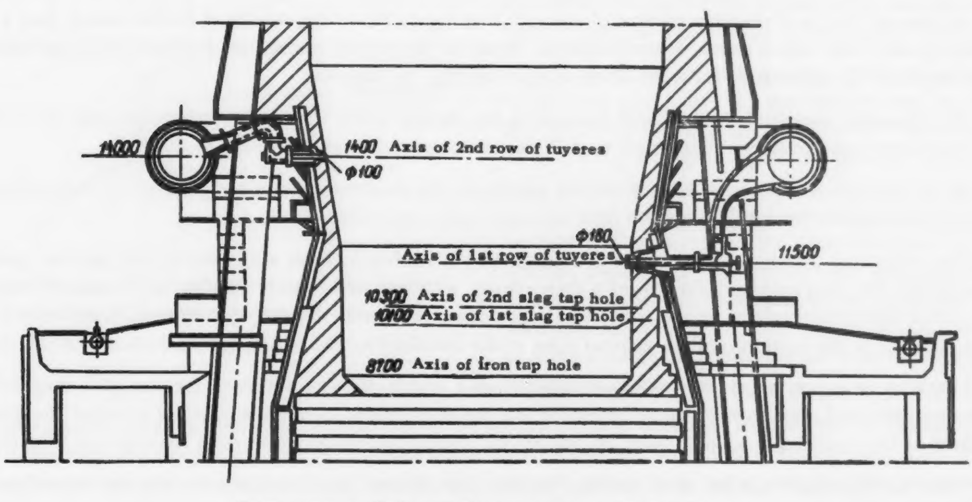
At first, these tuyeres were made of steel pipe with copper ends, 100 mm long; their durability was low due to the insufficient strength of the welded seam joining the end with the body of the tuyere. At present, they are made entirely of copper. Compressed air at a pressure of 4.5 atm or oxygen at a pressure of 8.0-8.5 atm was fed into the furnace through these tuyeres beyond the limits of the oxidizing zone.

The results of the operation of the blast-furnace during the periods of blasting with compressed air and oxygen are given in the table.

Characteristics of Blast-Furnace Operation during Particular Periods

Index	Period I (4-15 February 1961)	Period II (18 February-1 March 1961)	Period III (3-14 March 1961)
Productivity, %	100	109.3	115.6
Smelting intensity, ton/m^3·day	0.887	0.926	1.004
Coke consumption, ton/ton iron	2.105	2.006	1.976
Basicity of slag $CaO:SiO_2$	1.20	1.21	1.18
MnO content in the slag, %	14.77	15.44	15.98
Mn content in the ore mixture, %	41.3	41.4	40.95
Si content in the iron, %	1.10	1.06	1.13
Oxygen consumption, m^3/min	99	65	104
Consumption of compressed air, m^3/min	–	58	–
Temperature of the blast, °C	895	906	969
Pressure at the mouth, atm	0.230	0.244	0.542
Temperature of the mouth, °C	423	410	418
Standstill, hr-min	11–13	1–39	9–50

Note: During period I the furnace operated without using an intensifier in the central part of the hearth; during period II compressed air was used as intensifier; and during period III oxygen was used.



Arrangement of the supplementary row of air tuyeres.

As is evident from the table, when compressed air or oxygen is blown into the center of the furnace, productivity and smelting intensity increase appreciably and coke consumption drops. Moreover, in order to lighten the

work of the hearth, improve the distribution of gas flow, and intensify the process of smelting iron, a second row of air tuyeres was installed during the overhaul. Seven tuyeres in the second row, 100 mm in diameter, are situated in the bosh 2500 mm above the axis of the main row of tuyeres; hot air (see figure) is fed into the furnace through them.

In order to determine the influence of these tuyeres on blast-furnace operation, they were twice closed off, and operation with closed and open tuyeres was compared. In both cases where the second row of tuyeres was closed off, operation of the furnace was disrupted, smelting intensity dropped, and productivity decreased.

The special tuyeres, situated between tuyeres in the main row, improve the distribution of gas flow over the furnace cross section and ease operation of the hearth. Under smelting conditions involving a large quantity of slag, when one cannot successfully further force operation, installation of a second row of tuyeres permits total blast consumption to be increased without increase in pressure losses and, consequently, increases smelting intensity. Smelting intensity was increased by 2-3% by use of the second row of tuyeres.

REGULATING THE TAPPING OF MOLTEN IRON BY MEANS OF A CHANGING ELECTROMAGNETIC FIELD

L. A. Berte

Likhachev Avtozavod in Moscow
Translated from Metallurg, No. 12,
pp. 6-8, December, 1961

The problem of eliminating manual labor in those departments where the work involves transporting molten metal is a very important one. One of such departments is the casting yard of the blast-furnace. The high temperature and corrosive character of the molten iron, which dissolves many materials, does not permit the task of mechanization and automation to be resolved with ordinary mechanical apparatus. Affecting the stream of molten iron with the object of halting it and regulating the quantity or changing the direction, e.g. in the troughs of the casting yard of the blast-furnace, should be accomplished without contact.

At present, the most realistic method of contact-free regulation of the stream of molten metal uses a changing electromagnetic field which causes electromagnetic forces in the molten metal, the direction and magnitude of which can be regulated by instruments included in the circuit feeding the inductor.

The changing magnetic field induces currents in the molten metal which in turn interact with the field. This leads to electromagnetic forces which tend to pull the molten metal in the direction of the field.

At the Likhachev Avtozavod in Moscow, an apparatus, the electromagnetic trough (Fig. 1), for transferring molten iron by means of a changing magnetic field has been built and tested.

The bed of the trough, which is made of refractory, pressed blocks from a mixture of fireclay and graphite, is located above the inductor, which consists of a three-phase, water-cooled tubular winding and a meshed magnetic circuit. It is closed from above by thermally insulated covers with built-in panel gas-burners, intended to maintain the temperature of the molten iron. A general view of the installation while in operation is shown in Fig. 2.

In testing an experimental six-meter section of such a trough, the iron followed the changing magnetic field both horizontally and also "uphill" when the trough was set at an angle. When the operator changed the direction of movement of the changing magnetic field, the stream of molten iron began to move in the opposite direction.

When the the trough was set in an inclined position (the molten metal moved upward under the influence of electromagnetic forces), the iron was cleaned of slag, which slid down the inclined surface of the stream. The electrical resistance of slags is much higher than that of molten metal; therefore, the currents induced in them by the field are insignificantly small, and the electromagnetic forces have practically no influence on them.

If the self-flowing troughs in the casting yard are replaced by electromagnetic ones, it is possible to direct the molten iron to any section and accelerate or stop its movement by simply switching the inductors below the corresponding sections of the troughs.

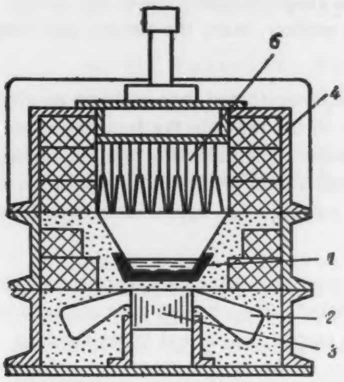


Fig. 1. Cross section of the experimental electromagnetic trough: 1) refractory lining; 2) winding; 3) magnetic circuit; 4) cover; 5) panel burner.

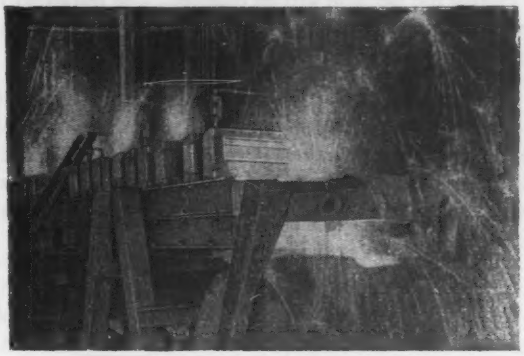


Fig. 2. Experimental electromagnetic trough during testing.

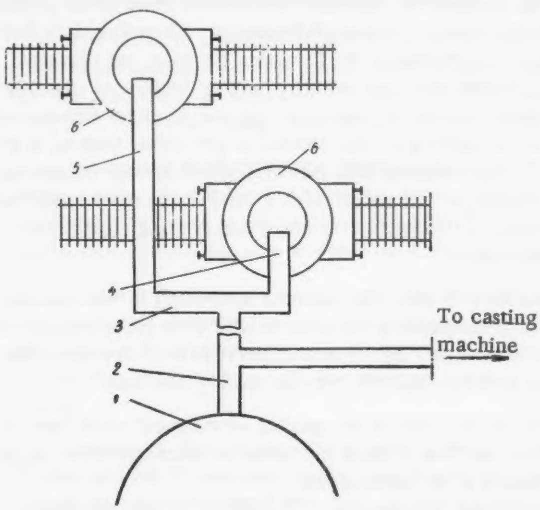


Fig. 3. Schematic of electromagnetic troughs in the casting yard of the blast-furnace: 1) blast-furnace; 2) main trough; 3) transverse trough; 4 and 5) pouring troughs; 6) iron ladle.

In this case, in addition to the straight sections of troughs, it will be necessary to build "switches" for leading the molten iron from one trough to another. A schematic of a casting yard with electromagnetic troughs and "switches" for regulating the streams of molten metal is shown in Fig. 3. From the tap hole of the blast-furnace a straight trough carries the metal to the middle of a short transverse trough. Depending on the direction of movement of the changing magnetic field at the transverse trough, the metal is fed into troughs leading to the iron ladles. Subsequently, it will be possible to direct the iron to the main trough or pumps for transfer to the steel plant. A part of the molten metal can be diverted into a branch trough leading to the casting machine.

The schematic of the casting yard of the blast-furnace shown in Fig. 3 is only the first stage in the introduction of electromagnetic techniques. The usual method of closing the tap hole and rail transport for carrying iron is still used here. However, working conditions in the casting yard are basically changing: the furnace attendant does not have to direct the movement of the smelted metal while working in close proximity to it. The troughs can be closed with covers to prevent heat loss, and the working space of the furnace attendant will become a panel for regulating the inductors of particular sections of the troughs.

The experience of the Likhachev Avtozavod has shown that scrap is deposited on the fireclay-graphite lining of the electromagnetic trough in the form of a continuous layer of iron 5-8 mm thick which does not stick to the lining in the least. One can easily remove such an iron strip from the lining of the entire length of the six-meter experimental trough by simply raising one end of the strip. Even such easy removal of scrap is hardly required, since the hot metal flowing over the iron layer left by the preceding flow cleans the lining. The experiments have shown that the thickness of the scrap layer on the electromagnetic trough after repeated flows remains the same as after the

first flow. A new system of heating is currently being mounted on the experimental installation at the Likhachev Avtozavod which should exclude the formation of scrap.

The next stage in the introduction of electromagnetic techniques will be replacement of the rail transport of molten iron by transfer along electromagnetic troughs or pipes utilizing induction pumps. Simultaneously, the system of closing the tap hole will be changed. The refractory mass will give way to an electromagnetic field, the use of which can not only open and close a path to the metal, but can also regulate its outflow, brake the stream, and interrupt it if it should be necessary.

Making an "induction tap hole" (as it is called in Gipromez) is much more complicated than building an electromagnetic trough. One must consider that inside the blast-furnace at the level of the tap hole the ferrostatic pressure of the column of metal is very high and is increased by the pressure of the blast. The induction pump blocking the outflow of iron through a refractory pipe (Fig. 4) must balance the arrangement's total pressure of 5 atm (abs). In addition, the cross section of the channel should be large in order to allow brief tapping of an appreciable quantity of metal.

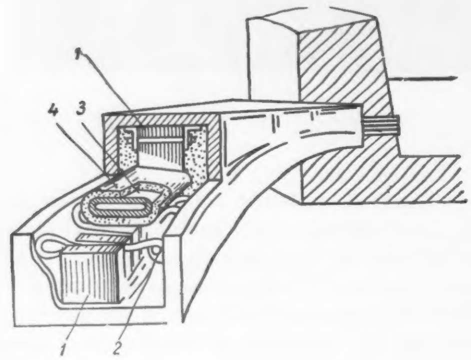


Fig. 4. Sketch of the induction tap hole. 1) magnetic circuit; 2) winding; 3) refractory pipe; 4) thermal insulation.

The second complicated task is the heating of the channel of the "induction tap hole". The channel does not need to be heated when the iron is tapped, since heat losses are compensated by the temperature of the molten metal. A calculation reveals that the temperature drop of the iron will not exceed several degrees. However, in closing the channel of the induction pump the metal may freeze; therefore, the channel must be heated. The most convenient way to do this is to use the same induction currents which cause the dynamical effect that maintains the flow of metal. However, induction heating requires feeding the inductors from special three-phase generators with current of increased frequency. Therefore, it is best to select a variation of the induction tap hole, not provided with a heating unit and not fully halting the flow of iron. Many specialists consider it possible to operate the blast-furnace with continuous tapping of iron, instead of periodical tapping as presently. They maintain that this may afford several technological advantages. Of course, such a variation is more suited both to making an "induction tap hole" and to using electromagnetic troughs and induction pumps for transporting the molten metal.

However, this solution requires a fundamental reorganization of the most involved technology in the blast-furnace industry. For the present, it will apparently be easier to introduce a variation in which the main mass of iron, which goes to the steel mill, can be tapped periodically. In order that plugs of frozen metal should not form in the channel of the "induction tap hole", a small quantity of iron will flow through it to the casting mechine.

High reliability of operation and the possibility of easy replacement of the quickly wearing-out units must be ensured for installations such as blast-furnaces. The simplicity and low price of the induction pump permit a supply of pumps to be kept ready. The operation of replacing a pump is to be mechanized.

The choice of refractories most resistant to corrosion by the stream of molten iron is very important.

A model of an "induction tap hole" has been built at the Likhachev Avtozavod which consists of an induction pump built into a barrel ladle in which molten iron is carried in the casting mill. The inventors propose to use it for the automation of teeming iron into molds moving on a conveyor. The testing of this apparatus will yield experimental data for designing a similar, more powerful apparatus for blast-furnaces; Gipromez has already begun such designing.

THE EFFECT OF RARE EARTHS ON THE FLAKING SENSITIVITY OF ALLOY MACHINE STEELS

A. M. Yakushev, Yu. V. Kryakovskii, E. I. Tyurin, S. P. Sorokin, V. I. Yavoiskii, and M. V. Glushtsov

Translated from Metallurg, No. 12,
pp. 9-11, December, 1961

Flaking in steel is due to an increased hydrogen content, which gives rise to tensile stresses. The most important methods of controlling flaking are to remove hydrogen from the steel or to convert it into comparatively strong hydrides. It is known that the rare earths (cerium, lanthanum, neodymium, praseodymium, etc.), which are being used to an increasing extent in steel production, react readily with hydrogen, forming comparatively stable hydrides. According to Sieverts, at 800° cerium dissolves 14500 cm^3/100g of hydrogen and lanthanum dissolves 14300 cm^3/100g, which is about 5700 times greater than the solubility of hydrogen in iron at the same temperature. The stability of hydrides and consequently the solubility of hydrogen in the rare earths decreases as the temperature increases. There are practically no actual data on the effect of rare earths on the behavior of hydrogen in iron and steel and on the related defects.

To obtain more information on this problem the Moscow Steel Institute and the "Krasnyi Oktyabr'" Plant have run a series of laboratory and full-scale heats*.

The effect of additions of rare earths on the solubility of hydrogen in iron has been studied in heats produced in a special apparatus. We have shown experimentally that the addition of up to 0.3% cerium, lanthanum and neodymium has practically no effect on the solubility of hydrogen in molten iron. The results have also shown that additions of up to 0.5% do not change the amount of liberated hydrogen during crystallization.

We studied the temperature dependence of hydrogen solubility in alloys with a high (20% and above) content of rare earths. As can be seen from Fig. 1 the solubility of hydrogen in alloys of neodymium and cerium (about 80%) is comparatively low at temperatures of 1450-1550°; however it increases sharply as the temperature is reduced. A similar dependence was also obtained for alloys containing about 20% rare earths.

There is therefore no reason to expect that additions of rare earths in these amounts could eliminate steel defects connected with the liberation of hydrogen during crystallization. Furthermore, the sharp increase in the sorption capacity for hydrogen of alloys containing rare earths as the temperature is reduced indicates that if they are added to steel they will combine with the hydrogen which is liberated when the metal solidifies and will therefore prevent flaking.

In order to check these results under production conditions several experimental heats were run. Steels 37KhS, 38KhSA and 36G2S were smelted in open-hearth furnaces fired with natural gas with fuel oil carburation. The scrap process was used with about 40% iron and 8% limestone in the charge. On fusion the basicity of the slag varied between 1.8 and 2.0 and before deoxidation it varied between 2.7 and 3.0. The quiescent boil period was not less than 45 min and the rate of carbon combustion during this period was 0.004-0.010%/min. The steel was deoxidized and alloyed by adding blast furnace ferrosilicon, ferromanganese and high-carbon ferrochrome to the furnace and ferrosilicon (45 and 75%) and aluminum to the ladle. After adding the ferrochrome the metal was allowed to stand 20-25 min. The temperature of the metal before tapping was measured with tungsten-molybdenum thermocouples and in the experimental heats it was 1590-1610°. After standing in the ladle for 10-15 min the steel was bottom-poured into 6.5-ton molds. It took 4.5-6.0 min to fill a mold.

Samples were taken for hydrogen from the sleeker by means of quartz pipes in a number of heats during pouring.

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* Those taking part in the work were L. N. Permyakov, M. P. Lapshova, O. D. Petrenko, V. G. Volnyanskii, G. R. Opanevich, V. A. Grigor'ev and V. P. Bondarev.

The hydrogen content was 6.3-8.0 cm^3/100 g. It was determined by the method of moisture-less initial vacuum heating. The rare earths in the form of ferrocerium with 94-96% Ce and mischmetal, containing 45-55% Ce, 25-30% La and up to 15% of the other rare earths, were added through the central gate while the body of the ingot was being filled. Plates of mischmetal and ferrocerium of 10-15 mm thickness were broken up into 40 mm pieces. The amounts of alloy introduced were 1.5-2.8 kg/ton.

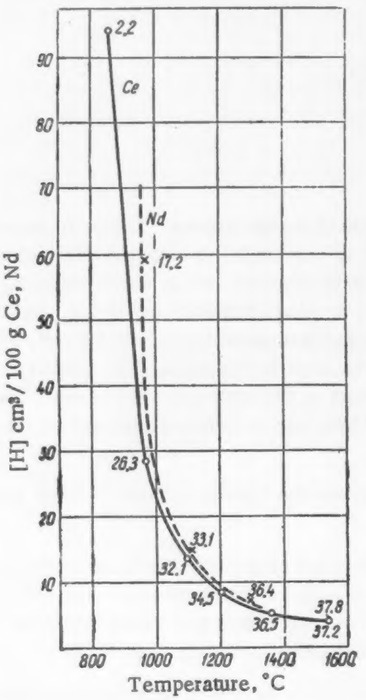

Fig. 1. Temperature dependence of the solubility of hydrogen in alloys with a high content of Ce and Nd (at a pressure of 38.0-2.0 mm Hg).

The ingots at 750-800° were placed in the soaking pits of the blooming mill where they were heated to 1150-1180° for 4-6 hr. The conditions for the heating and the rolling of experimental ingots did not differ from those used for the other ingots of the heat.

The ingots were rolled to a 195 x 225 mm billet. From the top or middle parts of the experimental and regular ingots samples were cut in the form of 400-500 mm bars, which were cooled in air.

After soaking for 5-7 days transverse samples were cut from the bars to check for flakes by the fracture method and from some of them longitudinal and transverse templets were prepared for etching to reveal the flakes. In the transverse samples the longitudinal fractures were 30-40 mm wide. The results obtained from the seven experimental heats are given in the table. By way of illustration to the table, Fig. 2 shows the fractures of quenched samples of some heats. The addition of 1.5 kg/ton mischmetal leads to a reduction in the flaking sensitivity of the steel but does not completely prevent the formation of flakes. Under the conditions of the experiment additions of 2.7-2.8 kg/ton prevented the formation of flakes. Additions of 2.0 kg/ton can partially or completely eliminate flakes in 37KhS steel.

From the experimental and regular bars of heats 4 and 2 (table) longitudinal templets were prepared, from heat 7 a transverse templet was prepared (etching with hot 50% solution of hydrochloric acid). Examination of the etched templets confirmed the data for the control of these heats by the fracture method.

Consequently, the introduction of rare earths in amounts exceeding 2.7 kg/ton can prevent flaking in 37KhS and 36G2S steels even with such a large profile as 195 x 225 mm and when the single blooms are cooled in air.

At the plant to prevent flaking the blooms of 37KhS and 36G2S steels are cooled in pits to give slow cooling over 84 hr. Slow cooling is also used after rolling in section mills. Consequently, by using rare earths we can cool the rolled stock rapidly, which means that the production cycle can be reduced, and less space will be taken up in the rolling mills; in some cases it will no longer be necessary to build special equipment for slow cooling and heat-treatment, etc. The conditions for the cooling of the rolled stock even

Comparative Characteristics of Fractures of Samples with the Addition and without the Addition of Rare Earths

Heat	Steel	Addition	Quantity, kg/ton	Characteristics of fracture	
				with addition	without addition
1	37KhS	Mischmetal	1.5	Separate flakes of average size	Many flakes of large and medium sizes
2	37KhS	FeCe	2.0	Single small flakes	Many flakes of average and small sizes
3	37KhS	FeCe	2.0	No flakes	Separate large and average flakes
4	38KhSA	Mischmetal	2.8	The same	The same, and small flakes
5	36G2S	FeCe	2.8	The same	The same, and many small flakes
6	37KhS	Mischmetal	2.8	The same	Separate large flakes
7	37KhS	FeCe	2.7	The same	Sample not tested

in open stacks are much more favorable than the conditions under which the samples from the experimental heats were cooled. Bearing this in mind it might be expected that these steels would not be prone to flaking with smaller additions of rare earths than in this case.

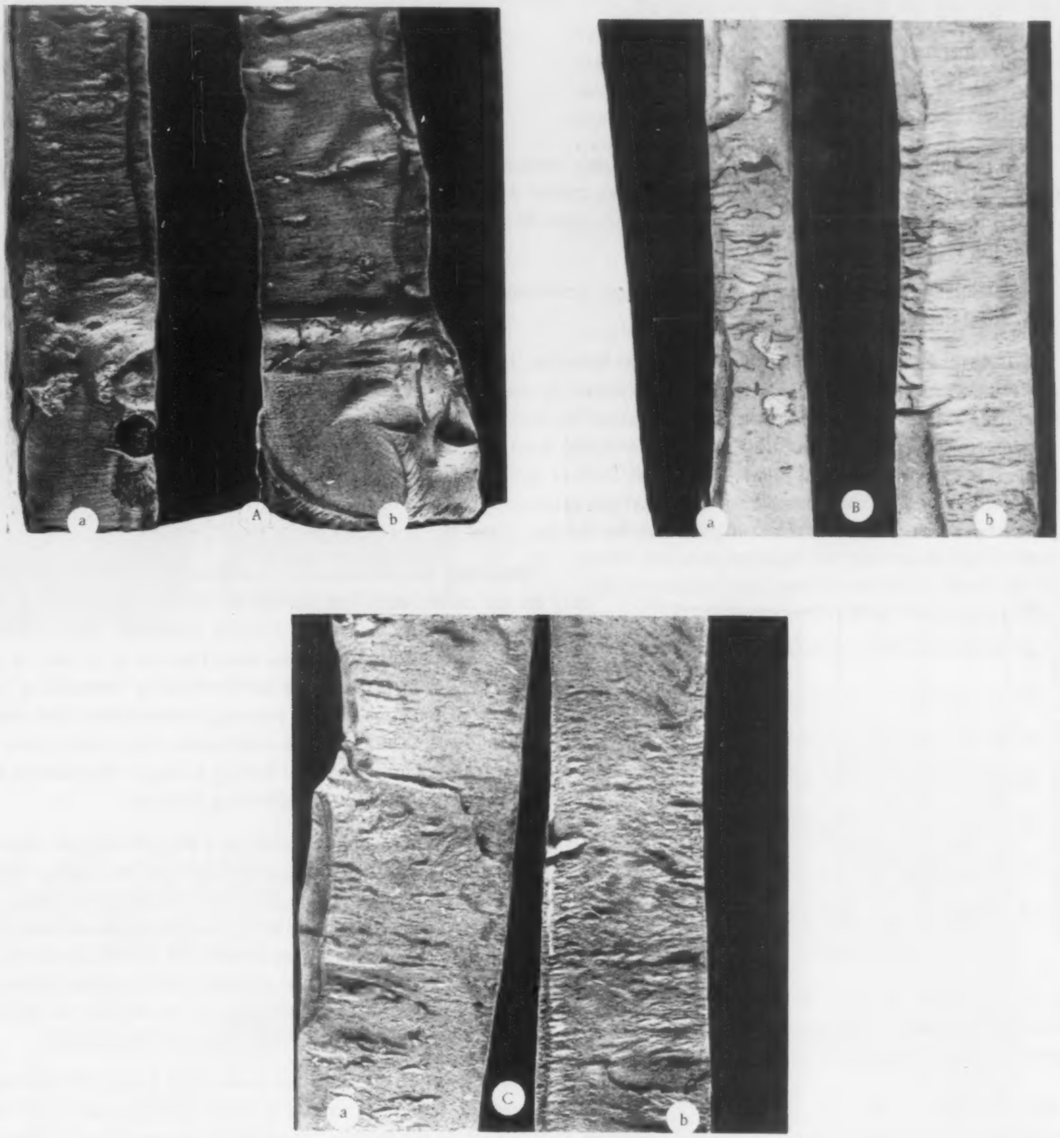

Fig. 2. Fractures of samples of heats 1 (A), 4 (B) and 5 (C) (table): a) comparative; b) with additions of 1.5, 2.8 kg/ton mischmetal and 2.8 kg/ton ferrocerium.

THE EFFECT OF THE MOLD ON THE FORMATION OF CRACKS IN CONTINUOUS INGOTS

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Novo Tula Metallurgical Plant
Translated from Metallurg, No. 12,
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In recent years Soviet metallurgists have made considerable advances in the continuous casting of steel. The most powerful installations in the world have been started and are successfully operating; when carbon and alloy metal is cast in them the yield of useful cast slabs averages 94-96%. Nevertheless, much remains to be done in the way of reducing rejects and metal waste.

Hot surface cracks represent the commonest technological defect in continuous ingots, as is the case for other carbon steel castings.

Experience in the continuous casting of steel at the Novo Tula Plant has shown that the degree of rejection of cast slabs because of hot cracks is largely determined by the design and care in assembly of the mold. Figure 1 shows the relative rejects of killed carbon steel cast slabs because of external cracks as a function of the carbon content for 7 molds with the same design (cross section 150 x 640 mm), the indices for the worst mold being taken as 100% rejections. It can be seen from Figure 1 that this form of rejection is mainly determined by the mold. Thus, for the No. 4 mold for all carbon contents in the metal the rejections because of cracks were 7-8 times higher than for the mold without a number, 3-4 times higher than for the No. 9 and twice as high as for No. 7, etc.

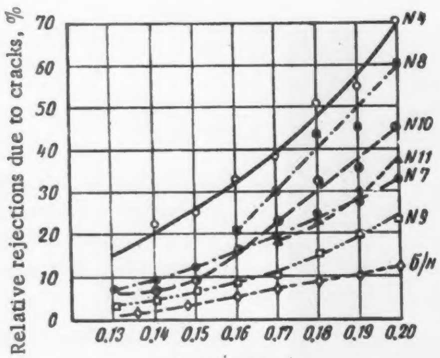


Fig. 1. The effect of the C content in the metal on the relative rejections of continuous ingots because of external cracks (for 7 molds).

However, the formation of cracks on the slabs depends not only on the mold design but also on its other parameters. In order to establish the place and time of crack formation, numerous experiments were performed to determine the rate of growth in the thickness of the skin of the ingot in the mold by introducing indicators into the liquid phase, and pouring. It was found that the first period in the formation of a continuous ingot takes place extremely unevenly, some sections having a larger thickness in the crystallizing skin than their neighboring sections.

A comparison of the obtained data showed that the unevenness in the thickness of the ingot skin is greater, the higher the ingot rejects due to cracks. Since the mold design is the same and the cooling of the perimeter of its working cavity is uniform, the difference in thickness of the skin around the perimeter of the ingot can only be explained by the washing action of the streams of metal and the unevenness in the heat removal due to the formation of a gas space between the ingot and the mold wall.

It was found that cracks are most often nearer the middle of the wide faces of the slab, probably due to the fact that this part of its perimeter is more highly stressed. In fact, the off-center delivery of metal to the mold reduces the washing of the middle, more highly stressed part of the ingot and therefore reduces the number of cracks without, however, completely eliminating them.

Figure 2 shows a "sleeve" obtained during metal breakout and the results for the measurement of its skin thickness at different distances from the level of the metal (arrows show the point where the metal was poured into the mold). Although the minimum thickness of the skin of the wide faces of the ingot is near the narrow faces, in the region of the washing action of the stream of metal the crack is closer to the center of the ingot, where its position corresponds to the least thickness of "sleeve". In this case the least thickness of the ingot skin, and hence the crack, may only be due to the formation of a gas space at this point, considerably reducing the cooling capacity of the copper wall of the mold.

The gas space can be formed either due to warping of the ingot skin or due to irregularities in the mold wall. In the first case this is connected to a certain extent with the properties of the metal being poured (linear shrinkage, thermal conductivity, etc.) which cannot be changed in the way which we require; in the second place it is connected with the rectilinearity of the mold walls and their ability to remain rectilinear during pouring.

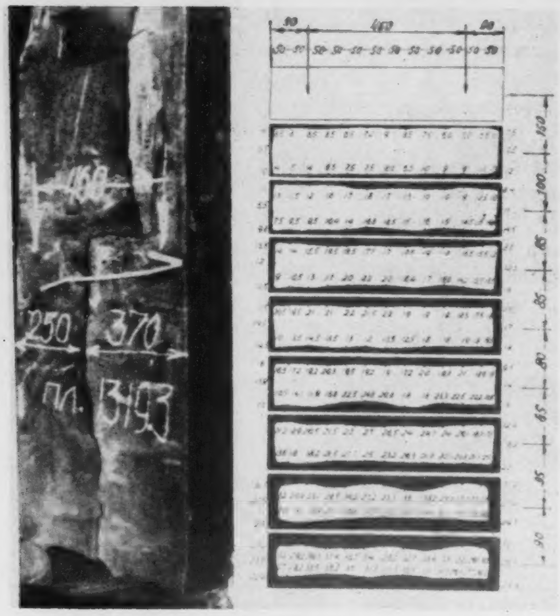


Fig. 2. "Sleeve" of continuous ingot: a) position of cracks; b) thickness of skin (mm).

To determine the effect of the gas space on the unevenness of crystallization and the formation of hot cracks on the ingot, thermocouples and thickness gages working on the principle of tensometry were mounted in the copper wall of one mold (Fig. 3). Thermopiles were used to measure the heat flow to the wide walls of the mold. The readings of the thermocouples, thickness gages and thermopiles were recorded by fast electronic potentiometers.

In order to determine the unevenness of heat removal around the perimeter of the ingot, the thermocouples were placed in rows along the height of the mold wall, all thermocouples of each row being switched on together. The switching system allowed the rows of thermocouples to be switched on synchronously with the motion of the ingot. Furthermore, to find the distribution of the thermal stream along the height of the wall the rows of thermocouples could be switched on with maximum speed. Before the experiments and also between the pouring of the heats a special instrument was used to carefully check the rectilinearity of the mold walls (after manufacture the mold walls differed from rectilinearity by up to ± 0.3 mm).

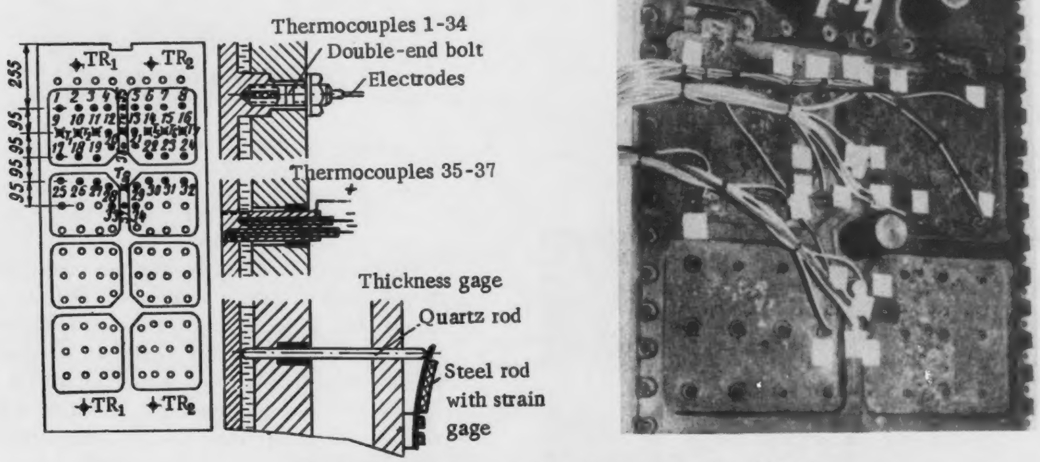


Fig. 3. Positions of measuring devices on the mold wall.

Experiments showed that during pouring the mold walls are deformed, their rectilinearity is disturbed still further, so that the deviations from rectilinearity of some sections of the wall reached 0.6-0.7 mm toward the end of the experiments, which coincided with the readings of the thickness gages. During pouring the walls' deformation was rec-

orded by thickness gages and at some sections it varied by up to ±0.3 mm. During the experiments a certain part of the working surface of the mold walls remained rectilinear.

The deformation of the mold walls has an important effect on the thermocouple readings and consequently on the heat flow from the ingot to the mold. Figure 4 shows the character of deformation and the temperature distribution along the width of a mold wall (thermocouples No. 2, 4, 7, Fig. 3). The thermocouples at the convex sections usually record higher wall temperatures (No. 4, Fig. 4), and the thermocouples in the recesses usually record lower temperatures (No. 2, Fig. 4). The readings of the various thermocouples change very little with time (4-5°) since there is constant heat transfer from the ingot to the mold wall. Very infrequently the temperature of the recessed part of the walls increases sharply for a short time (No. 2, Fig. 4, point A) and then drops to the former level. Similar temperature "peaks" in the "cold" sections are due to local breakout of the metal and the formation of characteristic double skins on the ingot surface (Fig. 5, a). In fact, when the rows of thermocouples are switched on synchronously with the motion of the ingot and the wall temperature is superposed on the ingots, the positions of the temperature "peaks" and double skin-breakouts coincide.

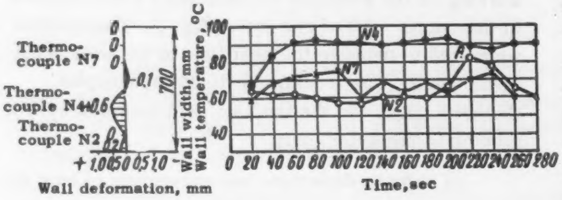
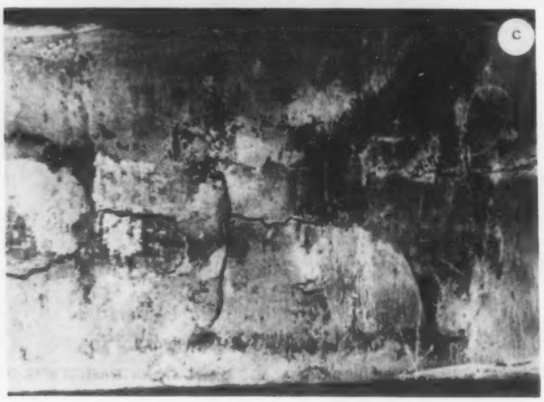


Fig. 4. Character of deformation of the wide wall of the mold and the change in its temperature during pouring.

Fig. 5. Surface defects on ingot: a) double skin; b) wrinkles; c) cracks.



The readings of the thermocouples placed on the rectilinear sections of the top part of the wall do not follow any rule. In some periods the wall temperature rises or falls (thermocouple No. 7, Fig. 4), which is due to the formation of a gap due to warping of the comparatively thin skin of the ingot. After the formation of a gap the skin is heated, loses its rigidity and under the action of the molten metal pressure it is again pressed to the wall of the mold, which corresponds to an increase in its temperature. The time of contact in this case is not constant and varies from fractions of a second to tens of seconds. The warping of the skin leads to the formation on the surface of a continuous ingot of shallow folds and pinchers (Fig. 5, b).

To determine the effect of irregular contact between the ingot and mold on the formation of cracks on the ingot, in the top part of one of the wide walls of the mold a 200 mm vertical groove was made, about 8 mm wide, of initial depth 0.3 mm. When the depth was increased to 0.6-0.7 mm linear longitudinal cracks appeared, the position of which on the ingot coincided exactly with the position of the groove on the mold wall. In this case the crack is formed due to the weakening of the ingot skin opposite the groove, due to its heating. This explains the role of contact between the ingot skin and the mold wall.

If a gas space appears at different points around the perimeter of the ingot and continues for a short time, it cannot cause cracks. However, if the disturbance in contact occurs at a certain point of the ingot perimeter and continues for a long time, this leads to a weakening of the ingot skin and the appearance of cracks. The prolonged existence of a gas space can only be caused by the presence of a deformed zone in the form of a "pit" or "hill" on the working wall of the mold, below the metal level, therefore the moving ingot skin does not reach the mold wall, is heated and tears. In this case the position of the cracks on the ingot will depend on the position and size of the deformed seotion of the wall; the wider it is the less oriented the position and shape of the crack on the ingot surface (Fig. 5, c). Hence we establish the connection between the molds of the same design and different rejects of cast slabs due to external cracks. Since rectilinearity of the working walls is not ensured during the manufacture of mold and during their operation, their degree of distortion depends to a large extent on the quality of assembly and the operation of each mold.

A small increase in the rigidity of the walls, possible without changing the mold design (increasing the thickness of the copper walls, strengthening their fastening to the iron plates) has sharply reduced cast slab rejects due to external cracks in the casting of killed low-carbon steel, and in rimming steel this type of reject has been completely eliminated and the yield of useful slabs has been close to the theoretical value.

For continuous casting installations producing wide flat slabs, we therefore recommend rigid molds (of the type used at the Novo Lipetsk Plant, with drilled walls, etc.), which have, at the present time, the best quality indices.

A NEW METHOD FOR LINING AND MAINTAINING THE STEEL-TAPPING HOLE

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of the Serov Metallurgical Combine
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pp. 15-17, December, 1961

Until recently the walls of the steel-tapping holes were lined in conjunction with the back wall. This system of lining prevented the replacement of the used walls of the hole during operation of the furnace. A new lining method has been found in which the hole is laid without arches. The initial working dimensions (width 130 mm and height 195 mm) are based on operation of the hole without ramming.

To a width of 130 mm (flat along the axis of the hole) the walls of the hole are laid without connection to the back wall (Fig. 1) on a refractory liquid paste consisting of 75% magnesite chrome powder and 25% refractory clay. This seals the seams and prevents metal penetrating into them. The normally permissible cross section of hole without correction is preserved after tapping 40-50 heats.

After descent of the metal and slag the hole is dried with magnesite chrome powder. Sinter or iron ore of the fraction up to 30 mm (layer thickness 70-100 mm) is then placed in the throat. The sinter is placed not in the hole itself but 50-100 mm toward the furnace from the top point of the hole. From the furnace side a layer of magnesite powder is placed on the sinter, from the rear side of the furnace the hole is also closed with magnesite powder and at its outlet there is a refractory plug of 75% magnesite chrome powder and 25% refractory clay (Fig. 2).

The sinter underlayer prevents the formation of ridges in front of the hole and ensures complete removal of metal and slag from the furnace. Closing the hole with sinter means that the heat can be easily tapped by piercing the magnesite skin with an iron poker. Oxygen is not needed to strip the hole.

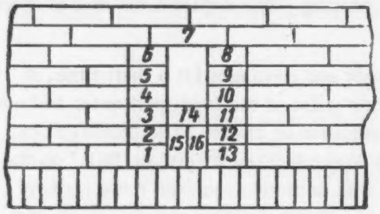

Fig. 1. Lining the walls of the hole: 1-16) bricks laid without connection with the back wall.

A steel-tapping hole less than 1000 mm long and more than 250 mm in diameter does not operate reliably and needs correcting. It is usually the throat of the steel-tapping hole which is most intensively worn. A large hole requires more materials for closing, causes a large metal stream during tapping and forms ridges which increase the wear in the top of the hole. We therefore had to find a method for correcting the throat during dressing without stopping the furnace to repair the hole.

The hole was closed by means of a sheet steel tube of 130 mm diameter and 800 mm length, filled with magnesite powder. To hold the powder, one end of the tube had curved edges and the other end was closed with a pasty refractory mass.

When the diameter of the hole became large, the steel tube was placed on the bottom from the rear side of the furnace; then the space between the tube and walls of the hole was filled with chrome paste. From the furnace side the throat of the hole was covered with a layer of magnesite powder mixed with 20% scale to a thickness of 30-50 mm. A refractory plug was placed at the outlet of the hole (Fig. 3).

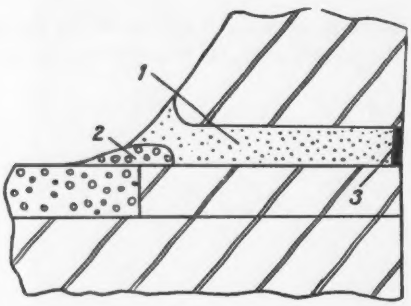

Fig. 2. Method of closing hole: 1) magnesite; 2) sinter; 3) refractory plug.

In the case of a short hole (less than 1000 mm) the sheet steel tube with the magnesite powder extended into the furnace to the required length.

The sheet steel tube is not removed from the hole; during routine dismantling the magnesite powder is taken from the tube and its walls are fused by the first metal streams. The refractory paste rammed about the tube is usually preserved and the hole acquires the normal cross section.

During the hearth repair after adding the sintering layers to the hearth a metal tube of diameter 130-150 mm, length 300-500 mm (Fig. 4) is placed in the neck of the hole. The space between the tube and the walls of the hole is usually filled with a chrome paste from the rear of the furnace; however if the hole had been enlarged considerably in cross section and shortened, it was also filled from the front side.

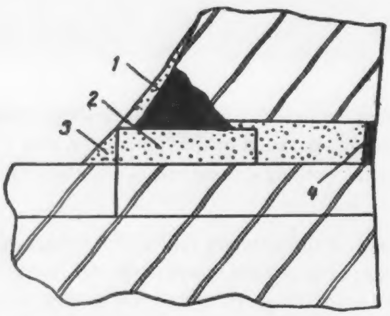

Fig. 3. Method for correcting large (but short) hole: 1) chrome paste; 2) sheet steel tube with magnesite; 3) magnesite powder; 4) refractory plug.

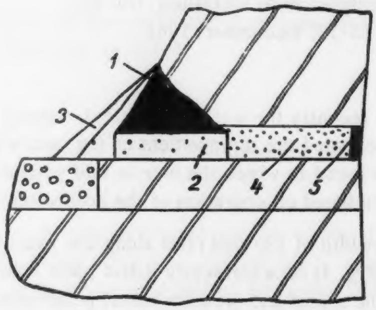

Fig. 4. Method for correcting hole during hearth overhaul: 1) chrome paste; 2) metal tube; 3) two layers of sinter; 4) magnesite; 5) refractory plug.

During the period of heating the sintering layer, two layers of magnesite powder with slagging by scale were placed in the neck of the hole on the chrome paste. After removing the excess slag formed during the slagging of

the sintering layer, the empty part of the tube was filled with magnesite powder. If the cross section of the hole at the outlet is normal, later it is closed in the usual way – without coating and ramming.

When the wall lining of the hole is 50% worn (65 mm on the side) the spent part of the lining is removed up to the tube (over the whole length of the hole) and lined again. The spent part of the top of the hole was covered with brick or, in rare cases, rammed with refractory paste.

The method for correcting the hole using a sheet steel tube ensures the formation of a hole with normal cross section and required length, increases the life of the hole, normal flow of metal and completeness of removal of metal and slag from the furnace.

AN UNBOUND JOINT OF A DETACHABLE SPOUT

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The spout lining used at the Serov Combine and the system for fastening it to the furnace reinforcement can be recommended for bifurcated and single spouts of the detachable type.

The joint of removable single or bifurcated spouts can be of two kinds:

a) the spout is installed on a special base at the rear of the working platform of the furnace and at the hole it rests on trunnions in the recesses of the reinforcement;

b) the spout is suspended on flexible structures to the crane beam of the casting bay and is tied by cables.

In both the first and second cases the spout is not rigidly fixed to the steel-tapping hole. The space between the lining of the hole and the spout (joint) is lined with firebrick in two flat rows over the whole cross section of the spout.

When installing such a spout in the furnace the joint between the spout and the furnace reinforcement must be carefully sealed and well dried. The system of lining with double overlapping of the joint is usual in any designs of refractory lining units where there is molten metal, as an essential condition, supplementing the rigidity of the reinforcement and ensuring the safe holding of the metal in the ladle or during flow along the spout. Lining the joint of two different linings of the hole and spout with firebrick is therefore unavoidable.

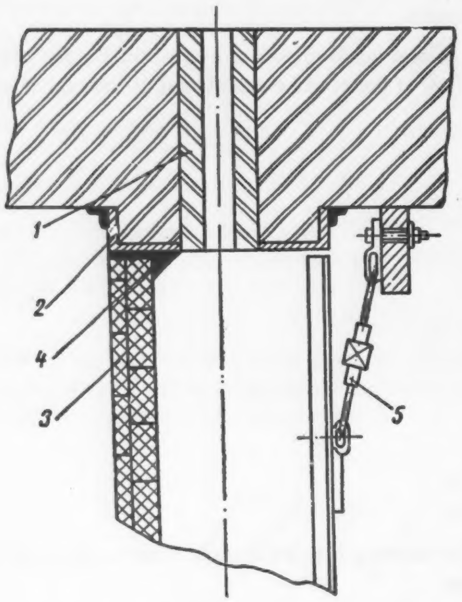
When the metal and slag have gone the spout is removed by mechanisms or is moved to the side on "strings".

The joint lining is broken mechanically: the brick lining falls into the slag car and the remainder is broken up during transporting and collection, since brick which has been used loses its mechanical strength. The lining of the joint between the spout and the hole can only be used to tap one heat whereas the lining in the spout itself withstands ten or more tappings.

In contrast to existing systems in this system there is rigid fastening of the reinforcement and lining of the spout with the tapping plate and the lining of the bottom of the hole. The firebrick lining of the bottom of the spout is connected with the magnesite lining of the bottom of the hole and the lining of the walls is connected without binding to the reinforcement of the tapping plate. The once-used refractory brick of the joint between the spout and the hole is replaced by a 5-10 mm thick refractory paste.

The refractory lining of the walls and bottom of the hole is installed separately. The spout is installed (or suspended) against the tapping plate with a gap between them of 100-150 mm. At the ends of the refractory magnesite lining of the bottom of the hole and at the side of the spout, a refractory paste of thickness 20-30 mm is applied, with

the following composition: ground chrome ore 80%, refractory clay mixed with water to a pasty consistency, 20%. After this the spout is joined to the tapping plate by rods with hooks, having "shackles" with right- and left-hand threads (figure).



An unbound joint between spout and hole: 1) split unbound lining of walls of hole; 2) plate of hole; 3) lining of walls of spout connected with reinforcement of plate of hole; 4) refractory paste; 5) "shackle".

When the shackles are turned the reinforcement and lining of the spout are firmly connected with the reinforcement and lining of the tapping plate, the bottom part of the spout lining is connected with the lining of the bottom of the hole and the lining of the spout walls is connected with the reinforcement of the tapping plate.

A straight joint is therefore formed without binding, where the function of the joint is performed by a chemically inert layer of paste tightened by the action of the shackles. After the shackles are tightened the excess paste is squeezed out of the joint and removed. The top part of the tapping plate is covered with a layer of paste to protect it from the metal. The working surface of the lining of the spout bottom should be joined to the lining of the hole 70-80 mm below the bottom.

After the heat has been tapped the rods of the tapping plate are removed from the spout, which is then removed by the mechanisms. In this case only the refractory joint of the paste is broken, the lining of the hole and the spout are preserved intact.

For the joint between the spout and hole the layer of refractory paste is removed from the ends of the lining and is replaced by new paste.

This system of joint between the spout and lining of the hole has eliminated breakdowns connected with the firebrick lining of the joint and hole and has reduced the consumption of refractory brick. Furthermore, the separate lining of the working part of the hole walls from the back wall of the furnace and the protection of the latter with a tapping plate make it possible to join the walls of the lining of the spout with the reinforcement of the tapping plate, rather than with the lining of the hole, which ensures operation of the lining up to the next general overhaul.

The operation of joining the spout has been considerably simplified and can be performed by an assistant steel smelter. Lining the walls of the hole separately reduces the material consumption and labor expenses and also makes it possible to replace a worn lining at any period of furnace operation.

IN THE STEEL MELTING MILLS OF THE SOVIET UNION

Translated from Metallurg, No. 12,
pp. 18-20, December, 1961

An Improved Method of Charging

Over the last ten years a group of workers in the open-hearth department of the "Zaporozhstal'" Plant has been trying to eliminate "bottlenecks" and seeking ways to increase the smelting production.

One of the more laborious processes in the department was charging. Arranging the furnaces in one line with a distance of 6-7 m between them considerably complicates the process. Here much depends on the senior charging specialists, who organize the delivery of charge materials directly to the open-hearth furnaces.

A few years ago only 20-22 heats were produced in a day. Rational organization of the work, the development of new production reserves and improved working of the furnace personnel have enabled us to almost double the number of heats. We now produce 40 heats per day.

A characteristic feature of the work in our department is now the speed with which all production operations are carried out.

It is well known that the first condition for a fast heat is fast charging. We have therefore kept the interruptions between delivery of the charge materials to a minimum. To accomplish this, however, serious difficulties have to be overcome. There were many such difficulties.

In the first place close contact was established between the senior charging specialists and the steel smelters. The work of the department immediately became better coordinated, being free of undue noise and commotion. This meant that the arranging and delivery of the necessary trains could be organized to the minute.

Whereas furnaces waiting for charge materials had previously stood for 20-30 min, the idle time was now reduced to 5 or, at most, 10 min.

It should also be mentioned that whereas previously the furnace was serviced by 2 locomotives it is now serviced by 3.

A few years ago the following state of affairs could have been observed in the department: a locomotive was being filled with water and during this time the cranes of the stock yard were idle, which in its turn causes idle time in the furnace. Close collaboration between the senior charging specialist and the steel smelter has eliminated these faults; the productivity of the stock yard has been considerably increased, since the locomotives are now only used for their designated purposes.

Previously, the metal trimmed from the slabs of the slabbing mill was loaded into three trains of 7 wagons each (150-160 tons); this was very inefficient since the fast charging of the heavy scrap was only carried out at three furnaces and at the other units lightweight scrap was charged. The charging then took up to 4 hr.

At our plant the following standardized procedure was introduced: standardized loading of charge with regard to weight and uniformity.

All charge trains were converted to 12 wagons. The total capacity of the molds was calculated as well as the proportions of materials used and the total weight of all charge materials. In addition, a strict order of charging was introduced at the furnaces: specified amounts of scrap were charged and specified amounts of iron were poured. The amount of trimmed metal used was 18-20 tons, scrap used was 8-10 tons, metal chips 4-6 tons, bales 10-15 tons; the remainder was lightweight scrap.

The workers in the stockyard were given strict instructions not to deviate from the standard procedure during charging. The weight of the charging trains was fixed at 78-85 tons.

The workers in the stockyard satisfactorily fulfilled one of their duties – charging by grades, but for a long time the workers of the department could not correctly observe the conditions for loading by weight: more than half the trains were overloaded or underloaded.

The administrative department brought in a new system of payment: for a standard train – 100%, for an underloaded or overloaded train – 50%. Each train not complying with the standard was immediately returned for correction. This, of course, created certain difficulties in the work of the department but the collective soon mastered the system of working. The increasing number of furnaces in the department, the increase in their productivity, the use of magnesite chrome brick and oxygen require ever-increasing loading speeds. There was a time when the loading of 10-12 trains per shift was considered a record. These figures are now much better. Increasing the speed of production brings with it an increase in the consumption of materials and an increase in the production norms. The charging workers of our department have successfully adapted themselves to these norms. Each year the stockyard brigade fulfils the production plan by 110-120%.

In the stockyard there have been changes of a technical and organizational character. Previously, all materials were fed along two tracks, situated to the east of the department, whereas the bunkers (a total of 8) in which granular materials were loaded for storage were on the west. Magnesite was loaded into one of the bunkers, bauxite into another and lime into a third, ore was loaded into a fourth, etc. The length of each bunker corresponds to the length of

only one car, and since there were many cars, naturally holdups developed on the tracks. In addition, cars with metal scrap were sent along these tracks. The shunting of the cars interfered with the work of the magnetic cranes; the loaders loading the cars with granular materials inadvertently contravened the safety regulations.

In 1959 a detour track was put into operation. Behind the stockyard building a concrete gantry was built on which all the charging of the cars is now carried out.

Two gantry cranes were installed to facilitate the work of the loaders. The bunkers of the stockyard are now always full despite the high rate of consumption of materials.

A special pit was fitted to store the iron. The reserves of iron in it are kept between 1500 and 2000 tons. If, for some reason, there are no cars from the local fleet or the MPS fleet, the cranes load the metal scrap directly from the pit.

The granular materials at the stockyard are now loaded from both ends.

Unfortunately, the railway organization on the east side of the department does not meet the present-day requirements. Whereas the furnaces on the west side of the department are supplied by three locomotives, the east side is supplied by two locomotives and it is this particular side which has the greater capacity furnaces. Time is often lost here due to holdups on the tracks.

In metallurgy minutes count. We can calculate how much metal is smelted in a minute and how much this steel will cost. If we combine the time lost in loading these furnaces due to poor development of the railway tracks, a considerable loss can be seen. The plant managers should bear this in mind.

In our work we use the method of ring supply: the empty car goes along one track and the materials are fed along another. This means that the charging can be uninterrupted (for 50-60 min), only one locomotive being used. The number of charging machines has now been increased to seven, which means that all furnaces can now be charged with two charging machines (three trains in 2.5 hr at the large capacity furnaces).

The steel smelters of the "Zaporozhstal'" Plant will continue to strive to increase the smelting of steel for the nation's needs.

V. Shumeiko, Senior Charging Specialist
of the Open-Hearth Department of the "Zaporozhstal'" Plant

Roof Sealing for Electric Arc Furnaces

At the Novo Lipetsk Metallurgical Plant at the beginning of 1959 80-ton electric furnaces were put into operation, equipped with 555-mm diameter graphite electrodes. The furnaces were intended for electrical steels.

Because of a number of serious faults the seals planned for the roofs of these furnaces were not used. Using the experience of other plants, water-cooled metal rings were installed, which had satisfactory durability in the smelting of carbon steels without the use of oxygen. However, when smelting transformer steel with the molten metal blown with oxygen, the rings were unreliable. When the metal was blown with oxygen particles of metal hit the roof, increasing the electrical conductivity of the roof, the metallic rings burnt out, the roof fell on to the molten metal.

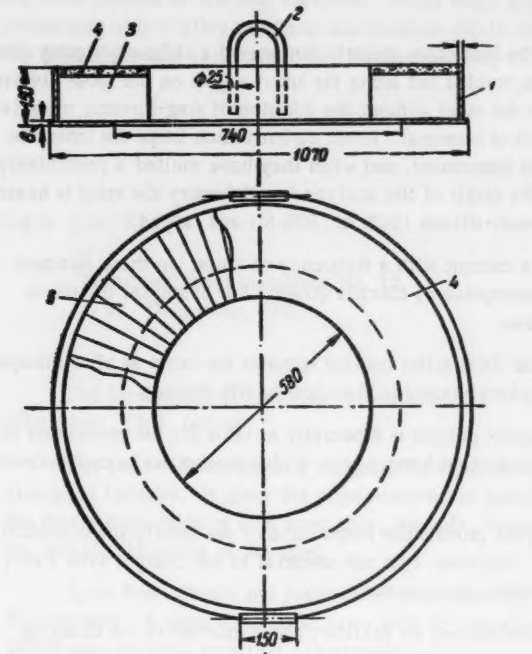
The average life of the rings did not exceed 10 heats, the quality of the metal deteriorated and the life of the roof lining was short.

B. V. Barvinskii, A. G. Zubarev, A. F. Turomshev, V. E. Ustalov and I. G. Chernyshov suggested a new method for sealing the holes between the roof and electrodes. The new seals were made of refractory material in the form of a ring freely applied from the top of the roof lining with a minimum gap about the electrode and with the use of excess gas pressure over this gap. The construction of the seals does not present any difficulties, the design is simple and reliable in operation.

The seal (see figure) consists of a metallic body of welded sheet carbon steel (St. 0, 2 and 3) 6-10 mm thick, having lugs for transportation. The inside of the body is lined with standard refractory brick KhM-2. The seams between the bricks and also the top face of the whole lining are covered with a mortar paste.

On the roof lining near the seal an area is laid with refractory brick; then the finished seal is dried for 2-3 hr in air and placed on the roof of the furnace. In the gap between the electrode and the seal gas is fed along a special tube, the gas stream leaving the tube, flowing round the electrode and providing a positive pressure over the gap and thus preventing the exit of furnace gases. At the present time the excess pressure is provided by compressed air which is fed along a tube with separation at the end into streams directed along the tangent to the surface of the electrode.

However, the unheated part of the electrode must be blown,otherwise the surface is oxidized. In cases where the plants have large-capacity oxygen installations, the surplus nitrogen from them should be used to give the positive gas pressure over the seal.



Roof seal of arc furnaces lined with refractory brick: 1) metal body; 2) lugs for transporting ring; 3) KhM-2 refractory brick; 4) layer of mortar paste.

Data on Water-Cooled and Other Seals (since Sept., 1960)

Type	Water-cooled metal seals	Other seals, lined with KhM-2 brick
Service life of seals, heats	5–10	80–90
Service life of roof lining, heats	60–70	95–115
Lost time in replacing one seal, min	8–10	4–5

During operation the inside walls of the seal are slagged over, giving additional sealing.

In small capacity arc furnaces (up to 30 tons) these seals can be used without having a positive gas pressure over the gas and slag wool should be used for the sealing, as when working with metal, water-cooled rings.

The comparative operating indices for these seals are given in the table.

These seals can be used in arc furnaces of varying capacity instead of water-cooled seals of different types.

A. G. Zubarev,
Novo Lipetsk Metallurgical Plant

OPERATION OF ELECTRIC FURNACES WITH THE DUPLEX PROCESS

Dr. Eng. Rudolf Shtefets

Translated from Metallurg, No. 12, pp. 21-22, December, 1961

At the Pol'di Plant, one of the United Plants in Kladno, much experience has been gained in the smelting of steel by the duplex process.

The combination of a basic open-hearth furnace and low-frequency induction electric furnace at this plant is used in two forms: two 5-ton open-hearth furnaces operate with two 5-ton low-frequency induction furnaces of the Kjellin type and two 20-ton open-hearth furnaces – with one 18-ton low-frequency induction of the Frick type.

The charge of an open-hearth furnace contains about 25% iron, the remainder is unalloyed wastes; 10% limestone is added to the charge.

In fusion, carbon content varies between 0.10 and 0.15%. Fusion in an open-hearth furnace using the duplex process differs from ordinary fusion in an open-hearth or electric furnace in the low carbon content on fusion for steels

with a high carbon content. After fusion the heat is deliberately oxidized until a forged disc sample does not have complete hot shortness, the carbon content usually being 0.05-0.10% and manganese about 0.15%. After the addition of 3-9 kg of ferromanganese per 1 ton of steel and slight rimming the steel is tapped. The period between the fusion and tapping is usually less than 30 min. On the spout the steel is deoxidized by ferrosilicon (up to 0.10% Si) and a small amount of aluminum (0.01-0.02%). The reduction in the sulfur content is slight, the phosphorus content before pouring into the induction furnace is usually less than 0.015%.

The steel from the open-hearth furnace is poured into the induction electric furnace by a ladle or directly along the spout. The open-hearth slag remains in the ladle or if the steel is fed along the spout a gate on the spout diverts it into the cinder pot. After pouring into the electric furnace the steel without the addition of slag-forming materials is carburized up to the required carbon content by the addition of charcoal. Rapid carburization helps the intensive whirlpool mixing of the bath. The alloying additions are then introduced, and when they have melted a preliminary sample is taken to determine the chemical composition. If the result of the analysis is satisfactory the steel is heated to the pouring temperature, deoxidized by addition of aluminum-silicon (20% Al, 50% Si) and tapped.

At the Pol'di Plant, for low-frequency furnaces we use a current with a frequency of 7 cps. In these furnaces the metal can be easily carburized; they have a very low consumption of electric power. For example, the power consumption of the 18-ton Frick furnace is only 86.6 kw-hr/ton.

A fault of the low-frequency furnaces is the fact that the final sulfur content remains the same as after the open-hearth furnace. A charge with a low sulfur content must therefore be used in the open-hearth furnace.

The open-hearth furnace and low-frequency furnace duplex process is especially suitable for the production of tool, spring and machine steels. In the 5-ton low-frequency induction furnaces the duplex process can be used to smelt stainless, antimagnetic and other steels.

In the open-hearth furnace and electric arc furnace duplex process the preparation of the semifinished product for this system is the same as for the system described above. However, it is not essential to use charges with a very low sulfur content since desulfurization takes place in the electric furnace also.

The steel from the ladle is poured into the electric furnace along an auxiliary spout inserted in the charging door. The temperature of the metal for the duplex process should be somewhat lower than for ordinary smelting. A carburizing addition made by grinding residues of carbon electrodes is added to the spout. The addition is calculated so that the carbon content increases from 0.05-0.10% to the required content in the finished steel. Steels with a low carbon content are used and are carburized to higher limits than is normal. Practice has shown that in this way it is possible to smelt machine and special purpose tool steels without spoiling their quality.

After pouring, the steel is heated without slag additions. After carburization slag-pouring additions are added, those usually used for the formation of refining slag. At the Pol'di Plant the bath is first deoxidized by an addition of 0.2% manganese-silicon.

Since the electric furnaces only deal with refining slag, the walls and hearth of the furnace are not saturated with oxidizing slag and during refining a low content of FeO is rapidly reached in the slag. The slag is formed from the initial slag by adding crushed coke or electrode material to its surface. However, at the end of the heat the slag has a very low CaC_2 content. Diffusion deoxidation by silicon alloys is not usually used. Ferroalloys are added in the usual way. The required amount of granular ferrosilicon is added before tapping. Finally, the metal is deoxidized in the ladle by the addition of 0.1-0.2% calcium-silicon, or addition of aluminum, or aluminum in combination with calcium-silicon.

In the duplex process with an open-hearth furnace and 20-ton electric arc furnace the power consumption in the production of high-grade steels is 170 kw-hr/ton. The electrode consumption is also very low—1.5 kg/ton. Since only the refining process takes place in the arc furnace there are no peak loads in the circuit.

When the duplex process is used the production of electric steel is usually increased by a factor of 1.5-2.5. The ladles must be twice as large as in the usual production method. The requirements made of the charging cranes are also increased (also by a factor of 2).

In the duplex process much smaller transformers can be used for the electric furnaces. The operation of the electric furnace on increased charge in the duplex process is easier than when operating with a solid charge.

With regard to the load of the electric circuit it should be mentioned that the simultaneous operation of several furnaces using the duplex process does not introduce any difficulties.

The steels smelted by the open-hearth furnace and arc furnace system contained, under normal conditions, 5-6 cm^3 hydrogen in 100 g metal (after extraction at 650°) and the nitrogen is about 0.001% less on the average than for ordinary smelting.

To achieve high productivity with the duplex process the individual heats should not have sharp differences in the total content of alloying elements. When there are considerable differences between the heats, for example in the production of low-alloy machine and stainless steels, the organized operation of the production units (taking part in the duplex process) is disturbed and the productivity of the system falls.

NEW BOOKS

Translated from Metallurg No. 12,
p. 22, December, 1961

The Metallurgy of Steel. E. V. Abrosimov, I. I. Ansheles, V. A. Kudrin, Yu. V. Kryakovskii, V. I. Orlov. Metallurgizdat, 1961, 680 pp.

The book is intended as a textbook for students in technical colleges and can be useful for workers in the metallurgical industry. It gives the physicochemical principles in steel production processes. It deals with methods for the direct production of iron from ores, crucible, converter and open-hearth processes. Much space is devoted to casting and solidification of the steel.

Apart from theory and practice of steel-smelting processes the book gives designs of steel-smelting units and departments. A separate section deals with the organization of production, technical and economic indices and safety techniques for steel-smelting departments.

The book considers the possibilities for the development of the steel industry and various processes in the USSR and abroad.

The book can also be useful for workers in the machine building industry.

V.V.

The Continuous Casting of Steel. M. S. Boichenko, V. S. Rutes, V. V. Ful'makht. Metallurgizdat, 1961, 301 pp.

The continuous casting of steel is being used to an increasing extent in the USSR and abroad. This book gives a brief review of continuous casting processes and the present state of development. In addition, it considers designs of installations, theoretical problems connected with features in the solidification of steel in continuous casting. It gives the technological parameters in the casting of square, round and flat ingots, the characteristics of the structure and their quality. The book considers the technical and economic advantages and possibilities for development in the continuous casting of steel in the USSR and abroad.

The book will be of interest for a wide circle of workers in the steel-smelting industry.

V.V.

The Casting of Steel. D. A. Smolyarenko. Metallurgizdat, 1961, 256 pp.

This book gives the principles of the open-hearth process and methods for casting steel in modern steel-smelting departments.

It gives the characteristics of refractory, dressing and heat-installation materials and their conditions of service. It deals with equipment for the casting of steel and the actual casting process, including continuous casting, and also the preparation of trains with molds and channels.

It gives basic information on the organization and economics of production.

The book is intended as a textbook for technical college lecturers and can also be useful for students. It gives a list of terms used in steel smelting production.

V.V.

EFFICIENCY OF ROLL-GROOVE DESIGNS AND MECHANIZATION OF ROLLING ON THE 500- AND 280-MILLS

N. P. Skryabin, G. K. Trofimov, I. M. Kochetov, P. A. Baryshnikov, K.I. Anan'in, I. M. Shkurko, B. M. Mints, E. S. Pastukhov, and P. P. Zhelnin

Omutninsky Metallurgical Plant and the Ural Institute of Ferrous Metals
Translated from Metallurg, No. 12,
pp. 23-27, December,1961

Until recently rolling on the 500-billet mill and the 280-merchant mill was practically without mechanization at the Omutninsky Plant. Both of these mills are of the in-train type. The 500-mill consists of two three-high open-type stands with a maximum barrel diameter of the working rolls of 578 mm and 1500 mm long. The first rolling stand was equipped with a lift table at the rear of the mill, with a roll table at the front, and with a two-strand transfer. The 280-mill is arranged in two lines: the first, a 360-breakdown stand and the second, a finishing stand consisting of 7 stands. The working rolls of the 360-breakdown stand have a barrel length of 1200 mm.

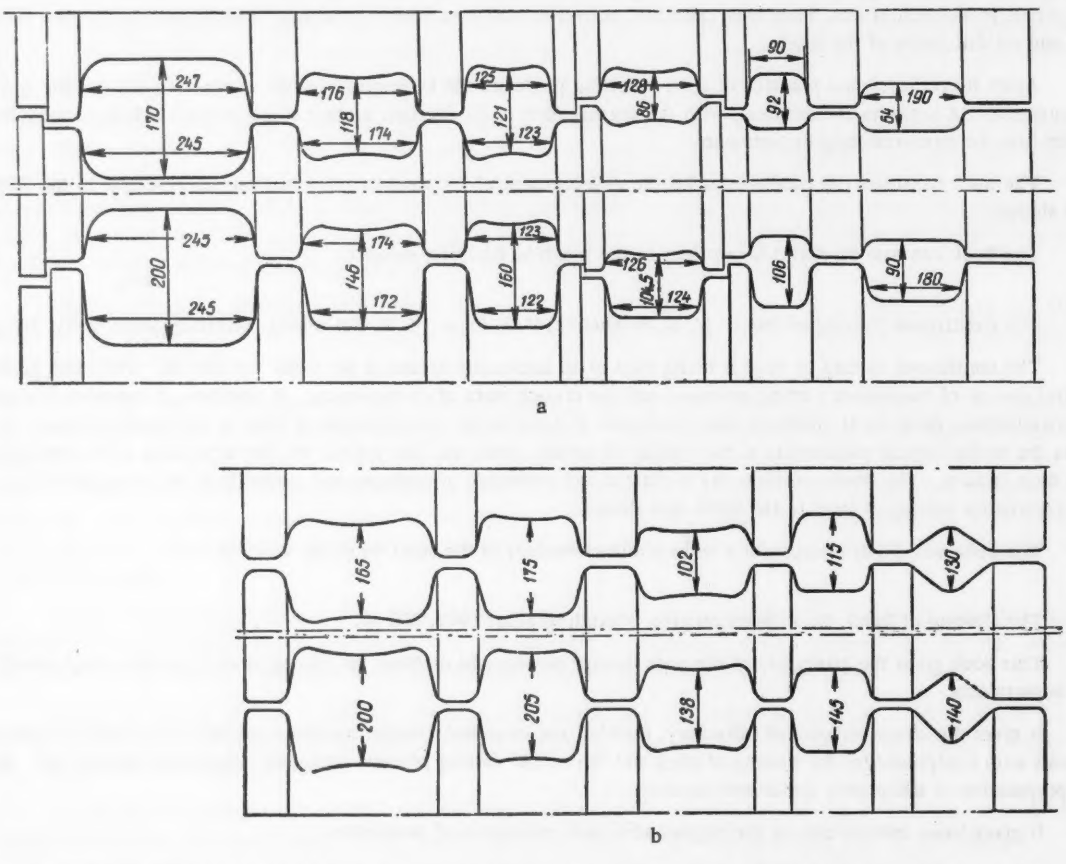


Fig. 1. Groove design of rolls of the breakdown stand of the 500-mill: a) Old; b) new.

The following shapes are rolled from common, tool, structural, and alloy steels on the 500-mill: sheet bar, strip 110-160 mm wide and 25-38 mm thick, squares 50-70 mm, squares with right angles 55-70 mm (All-Union State Standard 2591).

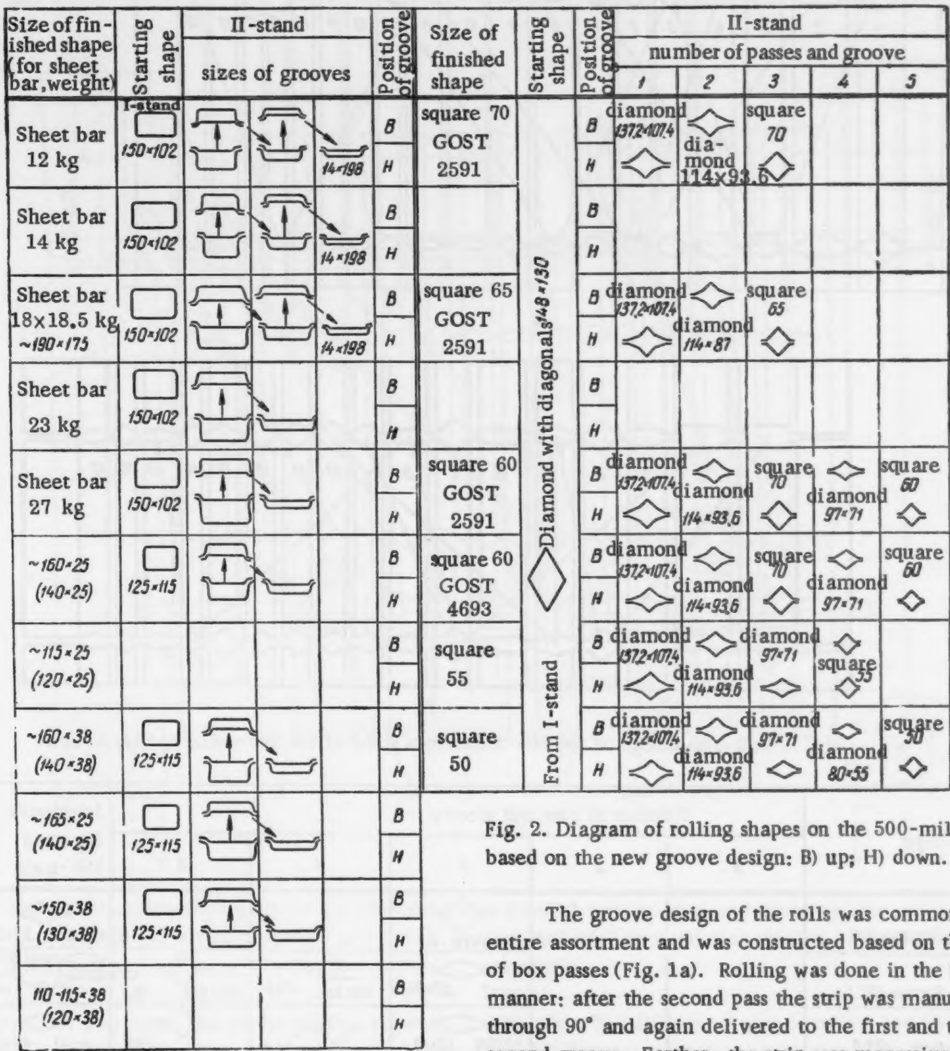


Fig. 2. Diagram of rolling shapes on the 500-mill based on the new groove design: B) up; H) down.

The groove design of the rolls was common for the entire assortment and was constructed based on the system of box passes (Fig. 1a). Rolling was done in the following manner: after the second pass the strip was manually turned through 90° and again delivered to the first and then to the second groove. Farther, the strip was successively fed to the next grooves with turns through 90° after each even pass. The width of the roll shoulders of the first stand was insignificant (65-75 mm). All this hampered the use of turning shields at the front of the stand.

When designing the new grooves of the rolls in the first stand we started from the condition of providing a successive rolling of the strip in the grooves and of a sufficient shoulder width in order to exclude jamming of the strip in the manipulating shields. In connection with this we redistributed the reductions by passes and increased the shoulder width. The number of grooves cut into the rolls of the first stand was reduced by two in comparison with the old groove design (Fig. 1b).

Rolling according to the new groove design is carried out in ten passes with turning after each even pass by means of manipulating shields. The new grooving of the rolls of the first stand is completely in agreement with the roll groove in the second stand (Fig. 2). A reduction of the number of passes in the breakdown stand permitted us to reduce ingot rolling time from 65.4 to 51.8 sec, to increase the output of the mill by 11.8%; moreover, this provided

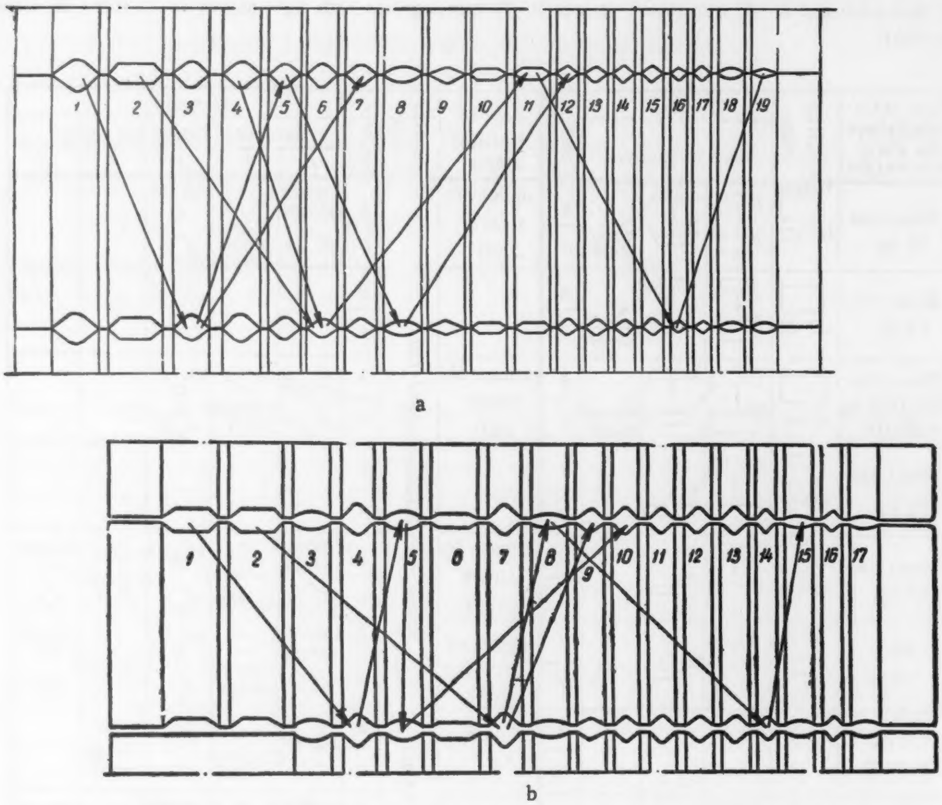


Fig. 3. Roll-pass design of the 360-breakdown stand of the 280-mill: a) Old; b) new.

Shape	Number of pass and groove 1	2	3	4	5	1st groove 1st stand 280-train
Square 35			square 35			diamond 53×30
Same 26.5			oval 50×24	square 26.5	square 26.5	oval 37×15 diamond 35×20
— " — 23.5			same 52×18	same 23.5	same 23.5	oval 32×12
Oval 38×12	hexagon 75×28	square 35	— " — 52×18	— " — 23.5	oval 38×12	squares 16-18
Same 52×18			— " — 52×18			same 23-24
— " — 50×24			— " — 50×24			— " — 26-28
Diamond 47×38			diamond 47×38			— " — 30-32
Hexagon 55×17			hexagon 55×17			squares 23-24 or underreduced square

Fig. 4. Diagram of rolling stock in the rolls of the 360-stand.

an increase in the output of rolled goods on the merchant and structural mills and on the sheet mills of the plant,which previously had not produced a sufficient amount of stock from the 500-mill. The quality of the goods produced was improved and a decrease in rejects on the mill by a factor of about three was achieved. The staff of roll operators, as a result of mechanizing the operation of the breakdown stand, was reduced by one man per shift. The breakdown is no longer a bottleneck.

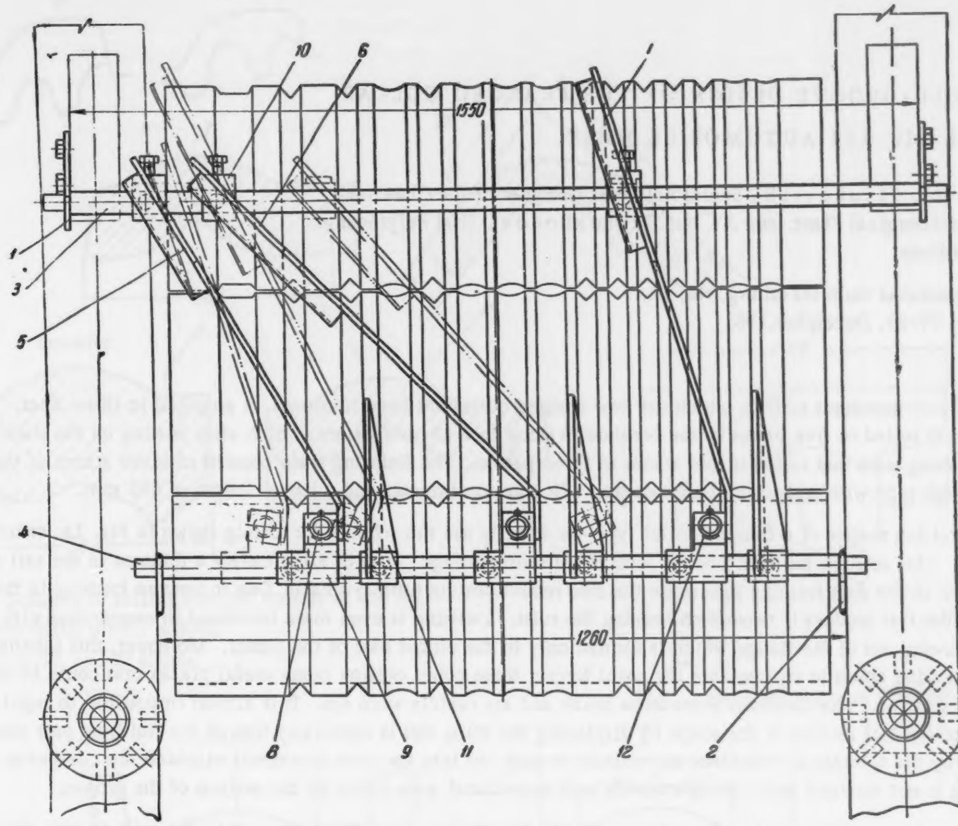


Fig. 5. Manipulating shields of the 360-breakdown stand: 1 and 2) Upper and lower cantilevers; 3 and 4) upper and lower traverses; 5, 6 and 7) first, second, and third manipulating shields; 8) pin; 9 and 10) lower and upper clamps; 11) shield-repeller; 12) cotton pin.

The 280-merchant mill of the plant is presently rolling about 200 different shapes from 50- and 55-mm squares. The stock is rolled in the breakdown stand in 3-5 passes (Fig. 3a),depending on the cross section of the shape delivered to the finishing train of the mill. The system and order of arrangement of the grooves and also the scheme of rolling the metal in the stand hindered the use of devices for the mechanized delivery of strip to the rolls without converting the grooves.

When working out the rolling scheme (Fig. 3b), we tried to align the grooving of the finishing trains of the 280-mill for the entire rolled assortment of shapes with the grooving of the breakdown stand, and to arrange the grooves in the rolls such that it was possible to install manipulating shields and to provide the simultaneous delivery of several strips to the upper line of grooves with the lift table.

Figure 4 shows the diagram of rolling stock for the 280-train in the 360-stand.

The 360-breakdown stand has: a lift table at the front, and at the back of the stand a roll table with manipulating shields (Fig. 5), the design of which makes it possible to regulate the angle of taper of each shield separately and its position relative to the grooves.

To deliver the strip to the first stand of the finishing train, a drive with shaped-rollers was installed which assured turning and delivery of any shape to the rolls.

The introduction of the new roll-pass design of the breakdown stand of the 280-mill and the installation of the new mechanism made it possible to reduce heavy manual operations and to increase the output of the mill by 2.9%.

OPEN ROLL-GROOVE DESIGN OF THE FLANGED COLLAR FOR THE ZIL-164 AUTOMOBILE WHEEL

B. M. Ilyukovich, Senior Roll-Pass Designer of the Chusovskii Metallurgical Plant, and A. N. Skorokhodov, Ural Polytechnic Institute

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The 250-merchant mill on which the new flanged collar has been mastered is arranged in three lines. A 95-mm square is rolled in five passes in the breakdown stand to a 43-mm square, which after cutting on the shears is sent to the finishing train and rolled in two stands in three passes. The finishing train consists of seven stands of the reversible two-high type with rolls of chilled cast iron 270 mm in diameter and a barrel length of 550 mm.

For rolling shapes of a flanged collar type we usually use the scheme for rolling shown in Fig. 1a, or one slightly altered. This scheme has a number of substantial shortcomings. First of all it causes a thinness in the tail section of the shape in the first forming pass since the side reductions are usually small. Due to uneven forming in the forming passes the flat product is twisted on leaving the rolls. Twisting is even more increased in connection with the decreased drawing out of the flange,which is formed only in the closed part of the passes. Moreover, this scheme provides for bearing cones to compensate the axial forces; these cones occupy many useful places that could be used for additional grooves. The shoulders sometimes break and are rapidly worn out. It is almost impossible to regulate the thickness of the tail section of the shape by displacing the rolls; this is especially true of the finishing pass where it is limited by the tolerance. This scheme calls for a deep cut into the rolls as a result of which the cementite surface of the rolls is not retained and a comparatively soft transitional zone forms on the surface of the groove.

These shortcomings can be eliminated partially by grinding the support cones until the rolls sit into the mill, by using grooved rolls, etc. Sometimes the leader pass is made closed; in this case there is a too indefinite filling of its tail section depending on the wear of the rolls and their alignment, and this leads to a considerable variation in the dimensions of the finished product.

Now the scheme of grooving of the flanged collar (Fig. 1b) has been mastered on the mill; in this scheme, due to the small projections of the shape, we used open passes with subsequent bending of the shape only in the finishing stand. The reduction factor in the first stand is 1.545, in the second 1.295, and in the third (finishing) 1.215 (delivery is 1.825).

The upper roll in the finishing stand must be closed, otherwise it is impossible to bend the shape. In the planishing stand, in order not to obtain an inverse slope of the end surfaces of the locking and tail sections of the shape during its subsequent bending, we used an upper parting of the rolls. This is not quite successful from the point of view of alternating the partings.

The width of the shape (size 32 ± 1, Fig. 2) for the templet of the finishing mill was taken as somewhat less than nominal. The length of the tail section, whose end surface was rounded, was selected close to the maximum size and is provided with free spreading. After determining the dimensions of the finishing groove, we found the dimensions of the open finishing pass by determining the radii between the middle part and the ends of the shape at a constant position of the central line. Then on the basis of the usual reduction factors we calculated the roughing groove: spreading was calculated according to the formula of B. P. Bakhtinov, taking 0.6 of the free spreading; the

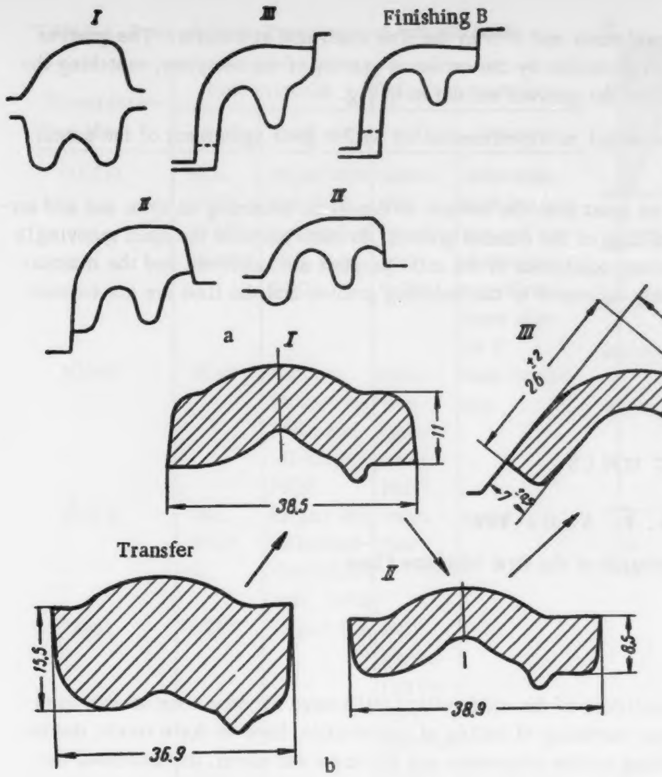

Fig. 1. Scheme of rolling flanged collars of the ZIL-164 automobile wheel: a) Old; b) new; II-IV and B) stands.

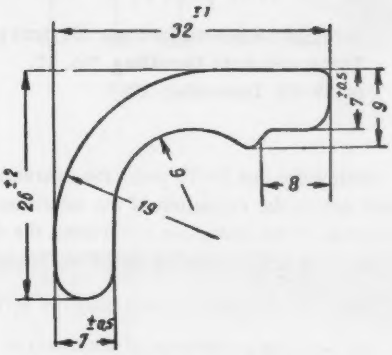

Fig. 2. Finished shape of flanged collar.

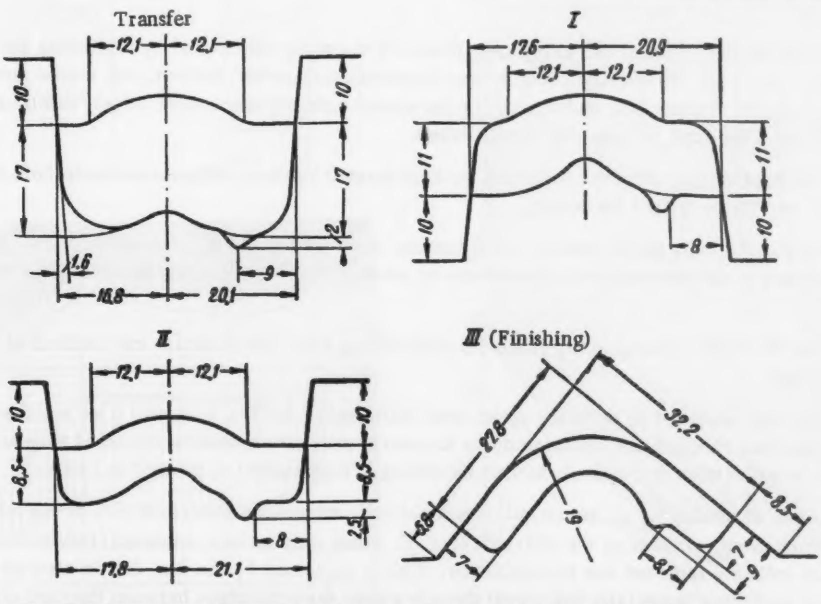

Fig. 3. Dimensions of templets of grooves for flanged collar: I-III) Stands.

outlet (i.e., slope) of the grooves is 7% in the second stand and 10% in the first stand and at transfer. The grooves are arranged in the rolls with their central line, determinable by the center of gravity of the templets, matching the middle line of the rolls. The sizes of the templets of the grooves are shown in Fig. 3.

While mastering the flanged collar shape we rolled an experimental lot with a good agreement of the actual dimensions of the templets with those calculated.

Of the shortcomings of the roll-pass design we must note the certain difficulty in obtaining an even and end surface of the locking part of the shape and the overfilling of the transfer groove. In other respects the open grooving is more expeditious than the usual grooving: the working conditions of the roll operators are improved and the maintenance personnel is reduced, the flat product is freely delivered to the finishing groove, and the flats are not twisted.

ROLL DURABILITY OF COLD-ROLLING MILLS

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Scientific Research Institute for Heavy Machines of the Ural Machine Plant
Translated from Metallurg, No. 12,
pp.29-33, December, 1961

During the last 10-15 years the operating conditions of the cold-rolling mills have become considerably complicated due to the expansion of the assortment, the mastering of rolling of low-ductile, hard-to-form steels, the intensification of the reduction conditions, the decrease in size tolerances and thickness variations, the increased demand for good surface quality of the rolled stock, etc.

Thus, the problem of increasing the service life of the rolls is of importance.

The working experience of a number of plants showed that rolls are put out of service as a result of natural wear and as the consequence of the formation of surface defects, which depend on the roll material and their operating conditions.

Roll defects can be divided into two categories: those which can be eliminated by regrinding and those causing the final rejection of the rolls. In the first category are: indentations (notches, hollows, tail marks), small ridges, a shallow network of cracks, shallow pits, and others. In the second category are: coarse ridges, exfoliation, fragments, cracks, fracture of the barrel and collars, and certain others.

At present the cold-rolling shops use rolls that are heat-treated by three different methods: bulk hardening, induction hardening, and flame surface hardening.

Bulk hardening is the most tested method which permits the manufacture of good quality rolls. However, in view of its inefficiency it has been replaced everywhere by another method, induction hardening. Austrian firms use flame hardening.

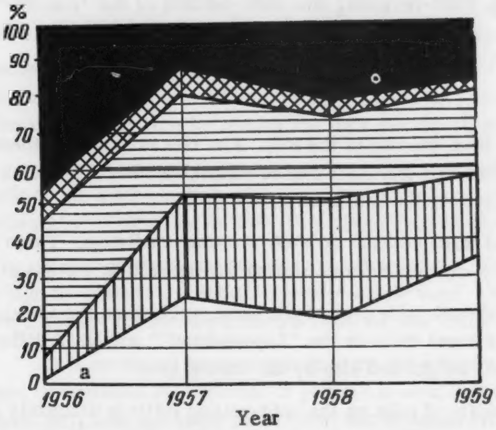
Table 1 shows the main manufacturing plants for cold-rolling rolls, the material and methods of heat treating the rolls at each plant.

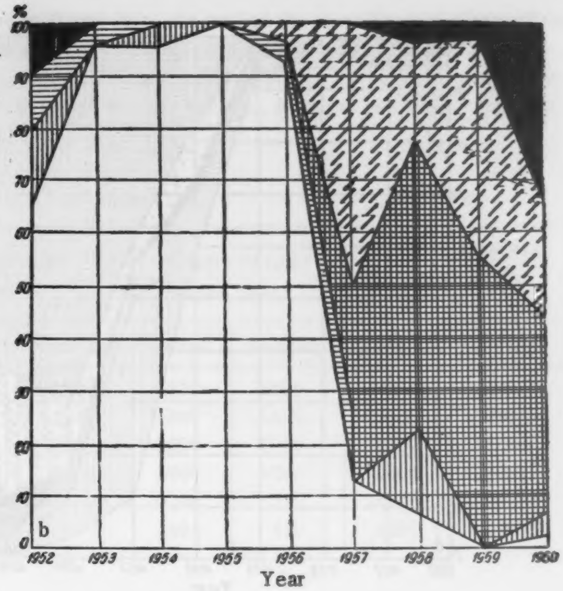
Rolls manufactured and used by different plants wear differently. In Figs. b, c, and d we see that in contrast to bulk-hardened rolls, most of which are eliminated due to natural wear, the induction-hardened rolls are usually put out of service due to exfoliation or cracks (induction hardening of rolls started to be used in 1957).

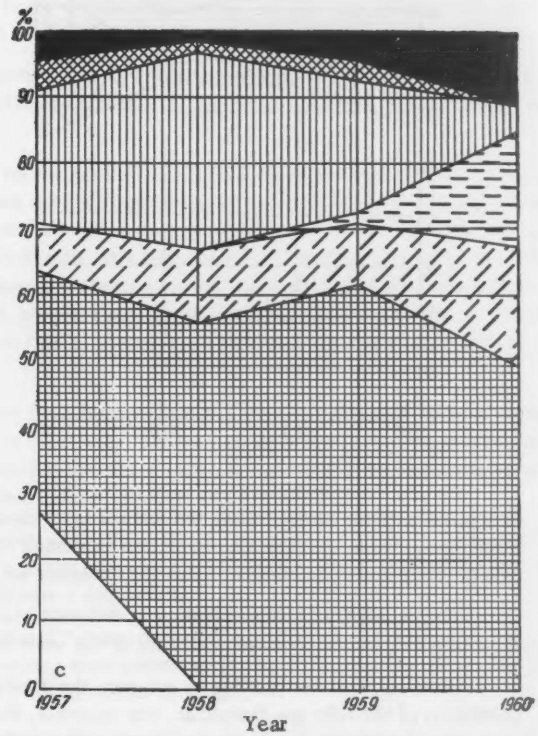
On the 740-mill of NMZ (Fig. e), where bulk-hardened rolls are mainly used, over 50% of the rolls are unserviceable due to natural wear, whereas on the 425-mill (Fig. f), where only surface-hardened (induction and flame) rolls are used, most rolls are removed due to exfoliation. This is explained by the fact that in contrast to bulk-hardening, with surface hardening (especially induction) there is a very sharp interface between the hard surface layers and the soft core; these sections of the rolls have the maximum values of residual stresses, and when a working load

TABLE 1. Data on Heat Treatment of Various Rolls

Manufacturing plant	Roll material		Roll heat treatment	
	work	back-up	work	back-up
UZTM	9Kh, 9Kh2, 9Kh2V, 9Kh2M	forged 9Kh and 9Kh2 and banded 9Kh, axle 55Kh	induction (previously bulk)	induction, bulk hardening and normalization (wt. of roll more than 22 t)
NKMZ	9Kh2	banded 9KhF, axle 55Kh and all-forged 9KhF	induction (previously bulk)	bulk hardening
ÉZTM	9Kh, 9Kh2	forged 9Kh, 9Kh2; banded 65KhN, axle, 55Kh	induction	same
Plant	9Kh2	forged 9Kh	bulk hardening (experimental induction hardening)	"
Izhorskii	9Kh, 9Kh2, 9Kh2M	–	induction (previously bulk)	–
Vőst and Bőhler (Austria)	9Kh2M, 9Kh2	–	flame hardening	–







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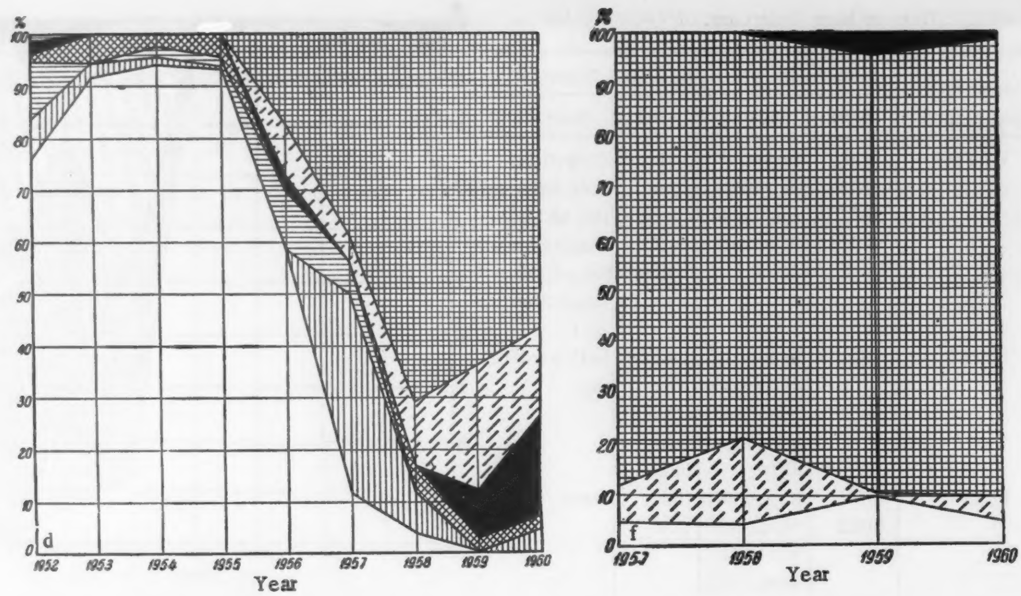
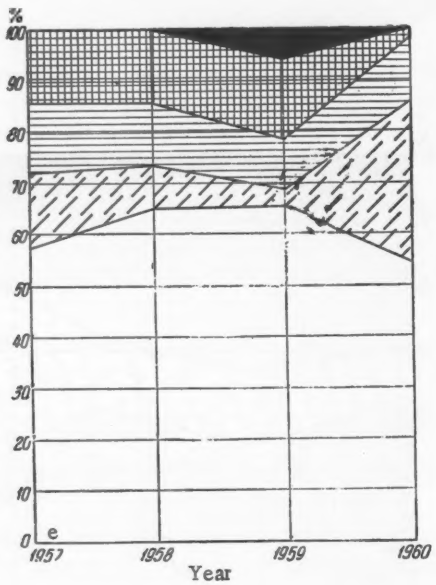
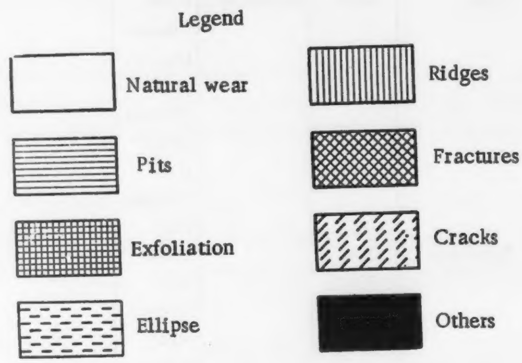






Distribution of roll unserviceability by types of defects on the mills: a) On the five-stand continuous 1200-mill of the MMP; b, c, d) respectively on the 1680-reversing, 1200-reversing and 1680-tandem of the "Zaporozhstal'" Plant; e and f) respectively on the three-stand 740 and the 425 at NMZ.

is applied to them during rolling the surface layer separates from the rest of the roll. The task in heat treatment manufacturing is to develop such induction hardening conditions that this fault can be eliminated and a sufficiently smooth transition zone obtained from the hardened surface layer to the soft core.

The durability of rolls operating at different plants and mills depends on their working conditions. Table 2 shows the data on the average durability of the work and back-up rolls for cold rolling during 1960 at various plants.

However, it is not possible to compare the durability of work rolls even of the same mills since the working conditions of the rolls are dissimilar. For example, the three-stand mills of the "Zaporozhstal'" and NMZ differ from each other both by the assortment of metal rolled and the roll weight and also by the rolling rate.

It follows from the statistical data cited that the durability of rolls on the cold-rolling mills is definitely insufficient and does not satisfy the increased demand of production. To increase the durability of the rolls it is first

of all necessary to use all available internal reserves of the mill and shop. At present the metallurgical plants of the country are working out various measures to increase the durability of rolls for cold rolling. Thus, starting from the specific operating considerations of each mill it is necessary to establish a definite sequence for between-stand transfer of the rolls during the regrinding process. For example, the sequence III-II-I (i.e., from the less loaded stands to the more loaded) is most widely used for three-stand mills.

TABLE 2. Durability of Cold-Rolling Rolls

Plant	Mill	Roll diam., mm		Length of roll barrel, mm		Average durability of rolls for 1960, t/roll	
		work	back-up	work	back-up	work	back-up
MMP*	five-stand 1200	500	1200	1300	1200	9000	100000
	tandem 1680	490	1240	1680	1680	29000	500000
"Zaporozhstal'"	four-high reversing 1680	490	1340	1680	1680	2000	350000
	four-high reversing 1200	400	1300	1200	1200	1500	350000
NMZ	three-stand 740	520	1000	740	737	14200	183000
	three-stand 425	200	400	425	420	1600	31000

* Magnitogorsk Metallurgical Plant

The new rolls must be broken-in either on a levelling mill or on others, but with use of a light assortment and in the least loaded stands. Taking into account that the failure of the rolls frequently begins from the edges of the barrels, flat products of a different width are provided for in the assortment of the mills, so that as the edges deteriorate and cuts form, a change to rolling narrower flats is carried out. Many plants also observe the rule of pairing the work rolls, i.e., two rolls work together from the beginning to the end of their service life (if one roll isn't put out of service ahead of the other). When rolling stainless steel the "Zaporozhstal'" Plant uses P-28 (Breistok) mineral oil.

To increase the life of the rolls it is necessary to observe strictly a temperature regime which creates favorable conditions for roll operation, and also to make sure of its uniform cooling with a coolant and to check the condition of the nozzles.

To decrease the sharp temperature fluctuation of the rolls a number of plants preheat them by various methods (for example, in oil baths), and after removal from the stands they are kept from abrupt cooling by special felt jackets (NMZ). According to the technical specifications the rolls are not to be reground for at least 6-8 hr after removal from the stand. However, in some cases because of the lack of rolls, this requirement is overlooked and the hot roll immediately after removal is set on the grinder. In such cases a preheated cutting agent is used during grinding to lower the temperature fluctuations. It is necessary to watch after the quality of the edges and trim off the weldments on the flat stock being rolled. A ragged edge and weldments can be the cause of indents, ridges and other surface defects.

The rolls returned to the shop should be kept in storage for a long period (5-7 months); this will allow a certain decrease in the residual stresses. In addition, the longer the rolls "rest" between changes, the greater their durability. However, at certain plants the stock of rolls is at present insufficient, and a rational regime of their use is not observed. The inadequate area for storing the rolls and the small capacity of the grinders also hamper this.

A most important measure is the rehardening of the worn work rolls. The "Zaporozhstal'" Plant rehardened the rolls of the 1680-tandem mill which had rolled half of the average norm (about 15,000 t). After rehardening, the two rolls rolled 57,000 and 46,000 t, i.e., they "experienced" almost a double life.

Based on the initiative of the workers of the "Zaporozhstal'" Plant, tempering of the returned rolls which have a high hardness (H_S = 98-100) is now widely used. On tempering their hardness falls by 2-3 units and along with this the tendency for surface defects is reduced, and consequently the durability increases.

It is necessary to take into account the effect of subjective factors, such as the qualifications of the roll operators. Experience at a number of plants has established that there is a different consumption of rolls on one and the same mill with the same assortment, but different brigades. While carrying out investigations on the 4/100 x 150

mill of the Leningrad Steel-Rolling Plant, it was noted that 60% of the ridges leading to defects of the rolls were the fault of the operators, 30% due to the poor surface quality of the sheet, and 2.5% due to poor pickling of the sheet.

We must also dwell on the operation of the back-up rolls. As we see from Table 1, two types of back-up rolls are presently being manufactured: forged and banded. The experience of "Zaporozhstal'", NMZ, and other plants convincingly showed the advantage of banded rolls. In addition to higher durability they have a number of other advantages. For instance, it is simpler and cheaper to replace a worn band than to manufacture a new roll. The worn forged back-up rolls are used as the axle on the 740-mill at NMZ, and laying of the banding is done by the natural forces. Slipping of the bands from the axle is sometimes noted during rolling. To avoid this, NMZ increased the thickness of the band at the expense of reducing the diameter of the axle, after which slipping all but ceased.

Another experiment of the NMZ deserves wide propagation: the back-up rolls which became unserviceable on the 740-mill due to fragmenting and spalling are used on the continuous five-stand train of the 810 hot-rolling mill.

Consequently, when working with rolls it is necessary to take into account all factors influencing their durability and to introduce widely into production measures improving their working conditions.

To solve successfully the problem of increasing the durability of the work and back-up rolls a close association is needed between the roll manufacturers, the plants, and researchers.

IN THE ROLLING SHOPS OF THE COUNTRY

Translated from Metallurg, No. 12,
pp. 33-36, December,1961

A New Shape Mastered

The Omutninskii Metallurgical Plant has mastered the rolling of a crescent-shaped section in three sizes (21 × 4; 21 × 5; 21 × 6 mm) of 30KhGSA steel for repair of tracks (Fig. 1).

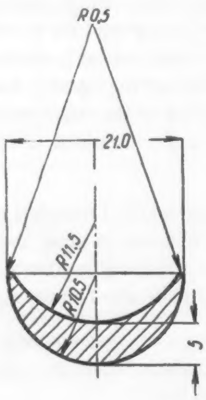


Fig. 1. Crescent-shaped section.

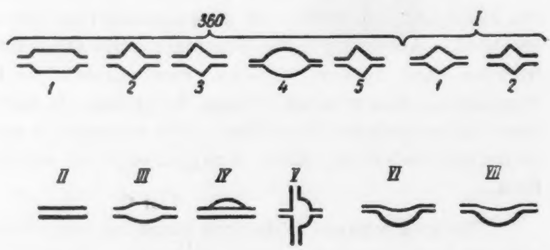


Fig. 2. Diagram of rolling shaped strips: 360 and I-VII stands; 1-5) passes.

Rolling was done on the 280-mill from a 50-mm square in 13 passes according to the diagram shown in Fig. 2.

The rolling temperature after the second pass was within 1120-1140°, the temperature at the end of rolling 880-900°.

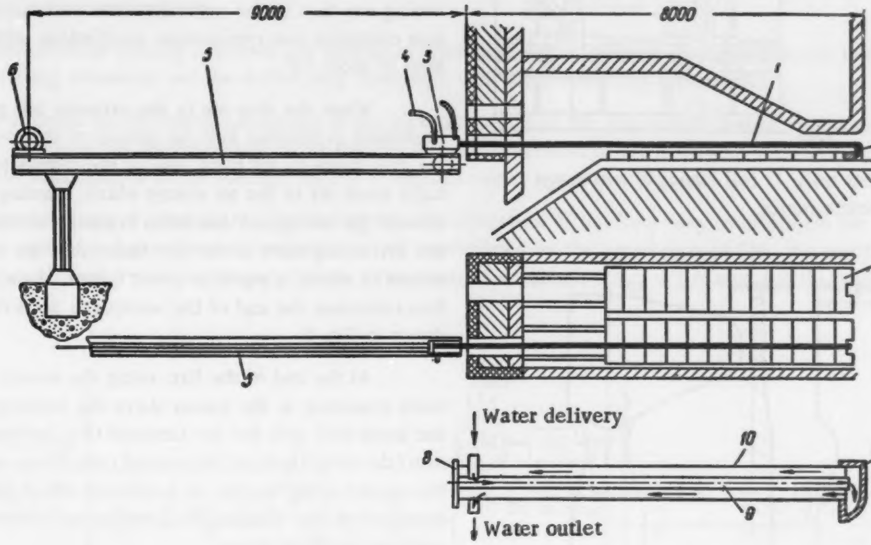
The steel corresponds to the technical specifications in shape and dimensions.

P. Baryshnikov, B. Mints, and A, Strelova
Umutninskii Metallurgical Plant

A Device for Ejecting Slabs from the Preheating Furnace

When repairing the mill and reheating furnaces, and also when cleaning the bottoms of these furnaces, the slabs must be pushed out of the soaking zone manually by means of hooks and special shovels. This laborious and heavy work takes much time and lengthens the downtimes of the furnaces for repairs.

To ease the work of the maintenance personnel and to reduce downtimes of the mill, the sheet-rolling shop at the Magnitogorsk Metallurgical Combine, based on the suggestion of V. M. Suprunyuk, G. G. Karaganov, and Ya. A. Ruzin, is using a special device with an ejecting rod (figure) driven by an electric winch. Before setting up the furnace for repair or for cleaning the bottom, the rod is passed through the port of the furnace and it seizes, by a beak, the last slab, into which is cut out an opening to accommodate the beak. A roller carriage is welded to the rod to facilitate extending it into the furnace.



Device for ejecting slabs: 1) Rod; 2) beak; 3) carriage; 4) rubber hose; 5) beam; 6) winch; 7) slabs; 8) stopper; 9) pipe; 10) rod casing.

When the winch is turned on the rod pushes the entire row of slabs onto the receiving rod table of the mill.

Prior to the introduction of this device, rejected slabs were charged into the furnace prior to cleaning and repair and these could not then be rolled to sheet since they were insufficiently heated. A portion of the fuel was wastefully consumed to heat these slabs (3 or 4 of them).

The rod can be cooled to ensure its long-term operation. The casing of the rod was made of thick-walled tube to which a stopper is welded on one end and on the other, a hollow beak. A smaller tube is placed and welded at one end inside the casing; cold water is fed to the beak through this tube. The water flows out from the cavity of the rod itself, thus preventing the rod from overheating and burning. The water is delivered to the rod and drained from it by a rubber hose.

The introduction of this suggestion made it possible to eliminate the heavy manual labor of the workers who extract the slabs prior to repair, to reduce the consumption of fuel and downtimes of the furnaces for cleaning the bottoms, since by means of this device the bottom of the entire soaking zone is freed for cleaning; this saves 2000 rubles per year.

V. P. Emel'yanov
Magnitogorsk Metallurgical Combine

Pendulum Mill

The ends of workpieces for pitchforks before they are turned into tubes are spread by flattening them on air or mechanical hammers, and then they are cut on presses to obtain the necessary configuration.

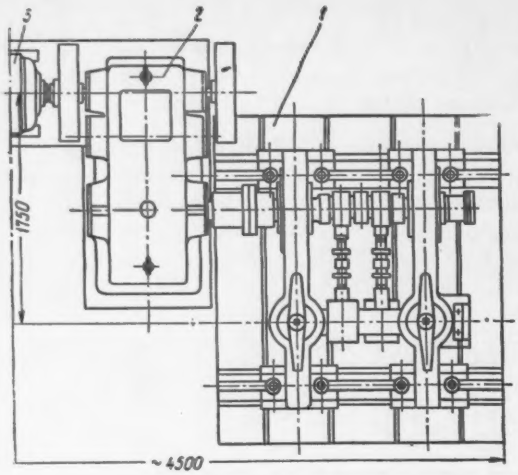
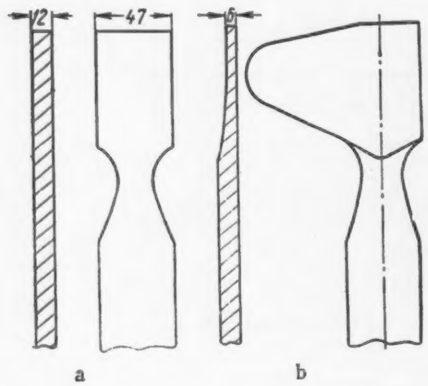


Fig. 1. Pendulum mill: 1) roll stand; 2) two-stage reducer; 3) electric motor.



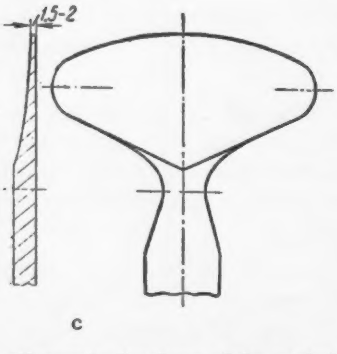


Fig. 2. Change in the shape of the workpieces on rolling: a) Workpiece; b) after first pass; c) after second pass.

The Automation and Mechanization Laboratory of the Vyksunskii Metallurgical Plant has developed a semi-automatic pendulum mill for transverse rolling of the end of the pitchfork blank into a tube. The mill (Fig. 1) consists of a roll stand, a two-stage reducer, and an electric motor. On the ends of the two rolls are attached the pass dies. In the lower die is cut out the groove whose configuration corresponds to the required configuration of the flattened end of the workpieces. The upper die has a corresponding projection. On the end of the lower roll is attached an air clamp for the workpieces. Adjustment of the length of the connecting rod is provided to align the grooves. During one turn of the crankshaft the work rolls with the dies complete two synchronous oscillations with an amplitude of about 72°.

When the dies are in the extreme left position, the workpiece is inserted into the groove of the lower side. As the dies move to the right, one of the distributors automatically feeds air to the air clamp which, starting operation, clamps the workpiece and holds it during rolling. During the first swing there is the first reduction, the average magnitude of which is equal to about 6 mm. As a result of the first reduction the end of the workpiece acquires the form shown in Fig. 2.

At the end of the first swing the second distributor starts operation as the pieces leave the forming zone, and the lower roll with the die fastened to it is raised about 4 mm (the magnitude of the second reduction), after which the second swing begins, as a result of which the metal is displaced to the side and the flattened end of the workpiece receives the final shape.

The third takes place with the same gap of the rolls; therefore the workpiece is automatically released by the distributor and drops from the die on leaving the forming zone.

The fourth swing is a blank, without a workpiece. At the start of this swing the distributor of the clamping device automatically starts operating and the lower roll descends to the starting position. At the end of the swing, at the extreme left position of the dies, a new workpiece is inserted into the groove of the lower die, and the cycle is repeated.

The output of the pendulum mill is about 1000 pitchforks per hour, which more than doubles the output of the air hammer. Moreover, the mill eliminates the operation of trimming since the flat product obtained has a rigorously determined configuration.

The mill can be used successfully in the production of articles requiring a comparatively large transverse spread. In this connection it will be necessary, of course, to change the working tool — the roll dies.

Yu. V. Bersen
Automation and Mechanization Lab. of Vyksunskii Plant

Change in Operating Conditions of Frequency Transformers for Roll Tables

The electric motors of the roll tables with individual drives for the continuous merchant and wire mills obtain power from frequency transformers.

The planned circuit (Fig. a) called for forcing the excitation of the generators to start the roll table. Under this condition the no-load voltage of the synchronous generator at an excitation current of I_{ex} = 5 amp was 250-270 v calculated such that at the time of no forcing and with a steady load its magnitude was 199 v (the rated voltage at a frequency of 24 cps).

It was necessary to do away with forcing since at the instant of roll table start-up the motors developed a starting momentum far exceeding the rated. For this reason the rocking parts of the motors were abruptly jolted, which put many motors out of service.

Elimination of forcing improved the operating conditions of the electric motors of the roll tables, but nevertheless the starting momenta and the difficulties associated with them remained appreciable.

To improve the operating conditions of the electric motors of the roll tables, master electrician N. E. Guba suggested changing the operating regime of the synchronous generators of the frequency transformers so that the start and smooth acceleration of the electric motors of the roll tables was in two stages.

With the changed scheme (Fig. b), during the idle operation of the frequency transformers the magnitude of the excitation current and the generator voltage will be conditioned by the parameters of ShR, the resistance of which according to this scheme is completely led in. The excitation current is I_{ex} = 1.5 amp and the generator voltage is about 130 v.

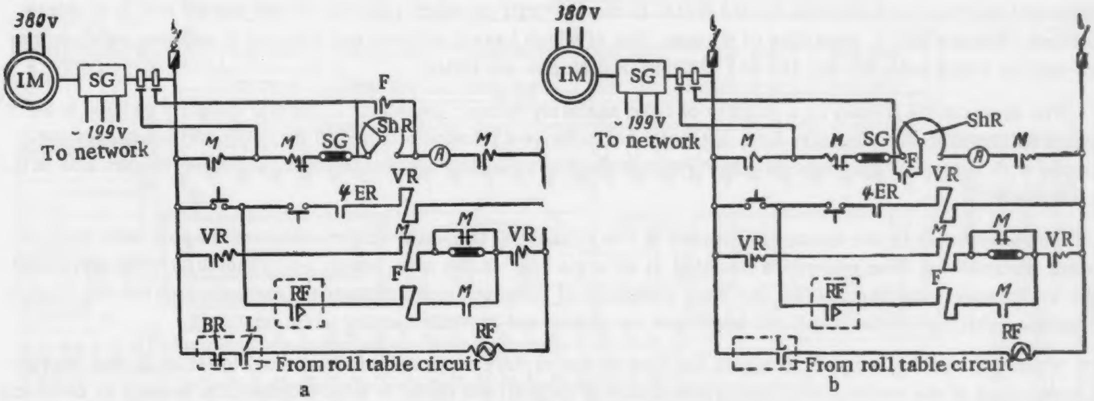


Diagram for the excitation of the synchronous generators: a) Before changing; b) after changing.

After the changes were made, the circuit operated in the following manner: when the roll table is turned on a stepped-down voltage is delivered to the motors, the magnitude of which drops from 130 to 90 v as a result of the voltage drop in the network from the start-up current. At this voltage the motors turn the roll table without a sharp jerking. Upon switching on the line contactors of the roll table there is a successive switching on of relay RF and contactor F due to closing of their normally opened contacts in the forcing circuit. Contact F shunts part of the resistance of ShR, as a consequence of which the voltage across the generator smoothly climbs to the rated. Simultaneously with the climb in voltage there is a further smooth turning of the roll tables by the motor up to the rated rpm.

Thus, the start and smooth acceleration of the roll tables by the motors are in two stages.

At present 792 electric motors on the four mills of our plant are supplied power from 24 frequency transformers with the changed operating conditions.

Thanks to the change in the operating conditions of the frequency transformers considerably fewer electric motors are put out of service due to mechanical failures, power consumption has been reduced and barrel wear of the rollers of the roll table has been decreased.

P. F. Datsenko
Krivoi Rog Metallurgical Plant

SECTIONAL FURNACES FOR HIGH-SPEED HEATING OF METAL

G. A. Podol'skaya, G. D. Karpov, and V. S. Shklyar

Translated from Metallurg, No. 12, pp. 36-38, December, 1961

Sectional furnaces are the most progressive of the presently existing reheating furnaces. Their use is especially alluring in high-quality metallurgy.

At the "Azovstal'" Plant, sectional furnaces (Fig. 1) were built in 1959 according to the design of the All-Union Institute for the Design and Planning of Metallurgical Plants in the shop for rolling milling balls.

Correspondingly, the capacities of the mills of the furnace have different characteristics. Furnace No. 1, having 5 zones of 4 sections each, provides heated metal to the 620-mill on which balls 40, 50, 60 and 80 mm in diameter are rolled. Furnace No. 2, consisting of 6 zones, five of which have 4 sections and the sixth 5 sections, services the 1040-mill on which balls 60, 80, 100 and 115 mm in diameter are rolled.

The furnaces are heated by a mixture of coke and blast-furnace gases with a thermal capacity of 2000 kcal/m^3, which is delivered to both furnaces from a general collector at a pressure of 200-250 mm H_2O. Both furnaces are equipped with burners of the "tube-in-tube" type: in the No. 1 furnace two to each side, and three to each side in the No. 2 furnace.

The workpieces in the furnace are moved in two streams by the water-cooled rollers of the roll table built in between the sections; these rollers are installed at an angle of 8° to the axle, which is perpendicular to the movement of the workpieces being heated (Fig. 2). Such a position of the rollers ensures rotation of the workpiece moving through the furnace, which promotes a uniform heating of its section and prevents curving while heating.

When the working tempo is disrupted the flow of fuel rapidly drops to a predetermined minimum, thus preventing overheating of the workpieces. During downtimes of the mill the metal is removed from the furnace to the changing table by reversing the rollers.

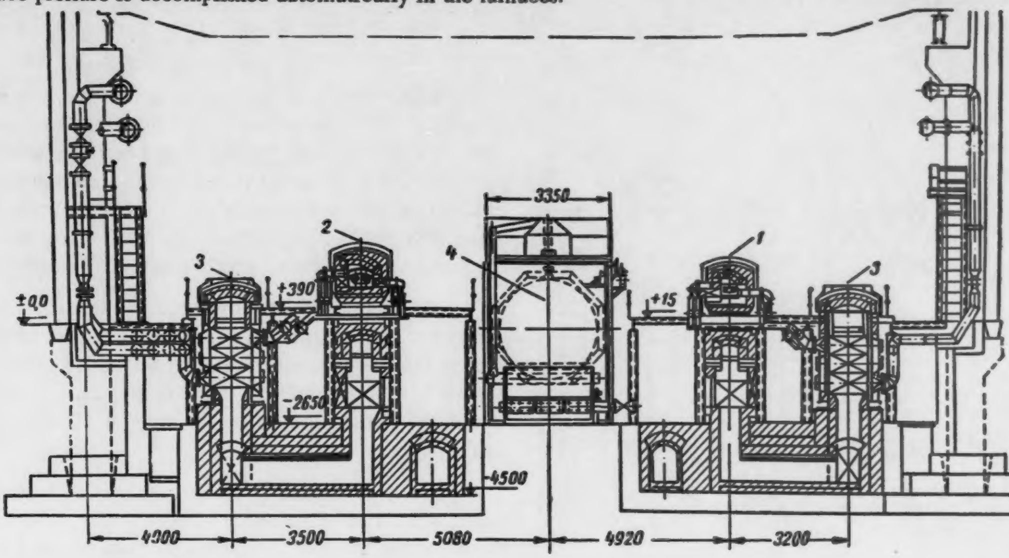
The tangential arrangement of the burners with respect to the workpieces ensures good circulation of furnace gases. A circular flow of combustion products forms around the article being heated. For a more uniform heating of the workpieces the arrangement of the upper and lower burners in adjacent sections is alternated. Especially effective is heating in the starting stage when the surface of the cold metal receives rays reflected by the lining surface, which has a high temperature.

The heating period for the workpieces is 1.5-2 min/cm of thickness.

The sectional furnaces are also convenient in that as the demand for metal decreases the first sections can be cut off.

The air for the sectional furnaces is heated in the recuperator-heat units. The combustion products are withdrawn through a central opening in the ends of the sections downward into the intersectional corridors. For reliable operation of the metal recuperators, evaporative coil packs of small diameter tubes were installed between the working space and the recuperators. Thanks to these packs, the temperature of the combustion products is lowered. The waste-heat boiler installed behind the recuperators works as a separator tank in the presence of the evaporative coil packs.

Regulation of the thermal load with respect to the temperature in the sections, the gas-air ratio, and the furnace pressure is accomplished automatically in the furnaces.



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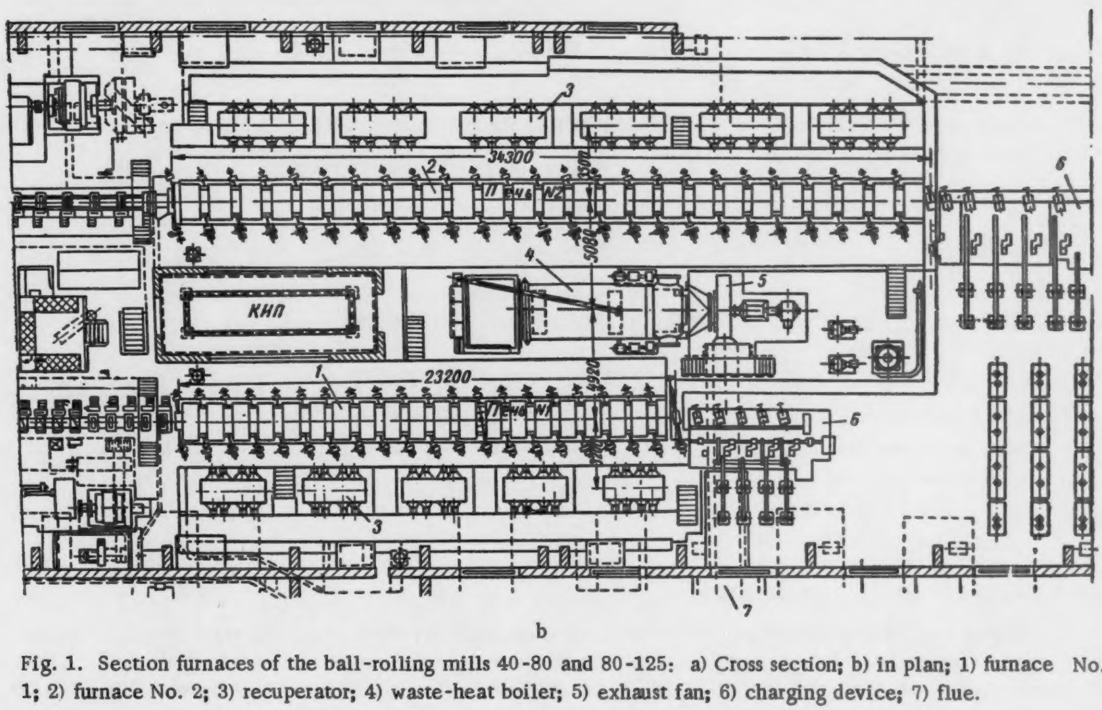

b

Fig. 1. Section furnaces of the ball-rolling mills 40-80 and 80-125: a) Cross section; b) in plan; 1) furnace No. 1; 2) furnace No. 2; 3) recuperator; 4) waste-heat boiler; 5) exhaust fan; 6) charging device; 7) flue.

But the system of regulation has its faults: the considerable inertia of the instruments, the absence of an instrument for determining the temperature of metal heating, the irrational placement of the instruments in the shop (the ratio regulator is at a great distance from the instruments—the flowmeters).

Due to the rapid heating of the furnaces and the rapid temperature changes (up to 400°), when changing from a working cycle to an idle one, the conditions of servicing the refractories are complicated. Here refractory mate-

rials are used that have minimum heat conductivity, neat capacity, and a high thermal resistance. The working space of the furnaces is lined with class-B fireclay brick with foam-fireclay insulation (based on the design). But as experience has shown, the durability of such bricking under furnace conditions of high-speed heating is not great, about 3 months.

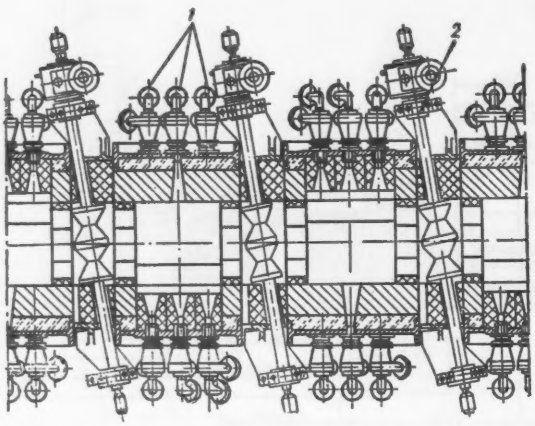

Fig. 2. Arrangement of burners 1 and rollers 2 in the furnace.

In the second campaign, the roof of the furnaces was lined with chrome magnesite brick; the walls and bottom of the sections, the throat and corridors with kaolinized fireclay (42% Al_2O_3). The walls were lined brokenly with chrome magnesite brick, the bottom was also lined with chrome magnesite brick. Such lining was still in satisfactory condition after 6 months of operation.

The heating regime worked out by the plant provides for operating the furnaces at comparatively low temperatures (1150-1300°), which satisfies the requirements of the mill for heated metal without substantially complicating the difficult conditions of servicing the refractory bricks of the furnace.

The heat balance of the furnace showed that the return of heat as heated air is 6.5%. The air is heated to no more than 150-260°. This is explained by the large heat losses in the coil packs of the waste-heat boiler (40.2%). In addition, much heat (16.9%) is lost by radiation and escape of gases through the ports and slits of the open corridors. Therefore, the furnace has a low efficiency of the working space (10%) and a comparatively high efficiency of the installation itself (55%).

At present the shop has achieved the planned output of the mill during rush hours when rolling balls 40, 60, and 80 mm in diameter.

THE SHAPE OF ROLLED STOCK AND CORROSION RESISTANCE

B. N. Bobrov

TsNILKhimstroi

Translated from Metallurg, No. 12, p. 39, December, 1961

The relation between the contour of rolled stock and corrosion resistance has not been taken into account when developing pass designs for merchant shapes.

Chemical-resistant lacquer or other types of coatings are the main means to protect steel structures. Experiments have been carried out which have elucidated the effect of sharp fins and corners of merchant shapes on the life of these protective coatings. The sharp fins and corners of shapes were rounded for the investigations. For comparison we selected ordinary specimens of the same shapes.

All specimens were cleaned similarly from scale and rust, coated in the same manner with chemical-resistant enamel, and placed under similar aggressive media.

As was shown by the experiment, the coating on sharp fins and corners in most cases was destroyed in half the time as those on specimens with rounded transitions of the surfaces. The destruction of the lacquer film is explained by the unfavorable conditions created on the sharp fins and corners as a consequence of the film's tendency to shrink

during its formation. This tendency to shrink, which is caused by the evaporation of the solvents and their change in structure, leads to internal stresses that are especially significant on sharp fins and corners. Under the effect of the internal stresses the film properties deteriorate; the film loses elasticity and becomes brittle. The coating loses its protective properties and cracks develop in it, thus facilitating the penetration of the aggressive medium to the surface being protected; corrosion of the metal under the film begins. In addition, as the metal oxidizes the volume

Effect of Magnitude of Radius of Curvature on Resistance of Protective Coatings (KhSÉ) in Aggressive Media

Aggressive media	Radius of curvature, mm	Test period, days						
		12	30	50	76	91	121	152
HCl 10%	1	Film swells on fin	Film swells and blow-outs form on fin					
	2	Without change					Point blow-outs	
	3	Same					Same	
	4	Same					Without change	
	5	Same					Same	
HNO_3 10%	1	Without change		Film swells on fin	Without change			
	2	Without change			Point blow-outs		Without change	
	3	Same			Without change		Same	
	4	Same			Same		Same	
	5	Same			Same		Same	

increases, causing stresses in the oxide film (rust). As a consequence of the inelasticity of the scale, it cracks and peels, first at places of greatest stress concentrations, i.e., on the fins and corners. The protective coating peels off along with the scale.

As a consequence of this, the anticorrosion coatings which protect the steel structures are prematurely put out of service, and only 65-70% of the potential protective capacity of these expensive coatings is actually used.

Experiments were carried out to determine the required radius of curvature for the shapes. Angular shapes with a radius of curvature of R = 1, 2, 3, 4 and 5 mm were taken for the experiment. The surface of the specimens was carefully cleaned from rust and scale, a coating (7 days soaking) was applied to all specimens in the following manner: one layer of VKhGM base coat and two layers of KhSÉ-1 enamel. The test was carried out in 10% acids (HCl and HNO_3) for six months. The effect of the magnitude of the radius of curvature on the resistance of the coating is shown in the table: already at a radius of curvature of 3 mm there is practically no negative effect of the fins and corners. Therefore, to ensure the maximum use of the potentialities of protective coatings it suffices to use on present shapes sharp fins and corners with a radius of curvature of 2-5 mm depending on the size of the shape. This measure will prolong the life of the protective coating and the steel structures.

AN EFFECTIVE MEANS TO IMPROVE WORKING CONDITIONS

(COOLING THE REGENERATORS DURING ROUTINE REPAIRS)

A. M. Spirina

Sverdlovsk Institute of Labor Safety
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pp. 40-41, December,1961

Acceleration of repairing the top and slag zone of open-hearth furnaces, which has been achieved by mechanizing the dismantling operations, also requires an accelerated repair of the regenerators. However, this is held up by the unfavorable working conditions in the regenerators.

The maximum opening of the end walls of the regenerators, the delivery of a large amount of air through them, and watering the checkers—all this, although it facilitates the work of the repairmen, still does not create favorable working conditions, especially during the initial dismantling period. This, of course, makes it necessary to postpone the start of checker dismantling from the time of furnace shutdown to repair by 1.5-2.5 days. However, this appreciably prolongs the general repair periods of the furnaces.

Deserving attention is the suggestion of V. M. Sobolev and S. E. Gershgorin,who see the solution of this problem in replacing high-speed repairs with long-time repairs by building reserve (substitute) furnaces. However, this measure cannot be quickly accomplished.

A method has still not been found for changing the checkers in the existing regenerators without people being in the regenerators. To improve working conditions during routine repairs of open-hearth furnaces, the "Uraldomnaremont" Trust started to use forced air cooling of the regenerators for 6-8 hr. This measure was approved and recommended for adoption by the scientific-technical conference on the organization of repairs of metallurgical furnaces and labor safety. However, there are no complete data on the effectiveness of this method.

In connection with this, at the end of 1959 and into 1960 the Sverdlovsk Institute of Labor Safety, the "Uraldomharemont" Trust, and the Nizhne-Tagil Metallurgical Combine began a joint endeavor to check the effectiveness of forced water-air cooling of the regenerators for medium repairs of large-capacity open-hearth furnaces.

Three cooling regimes were tested:

1) A six-hour preliminary cooling, delivery of air by a SIOT-7 fan unit at 30,000 m^3/hr, a water flow of 60 liter/min per chamber (the water is delivered by two RP-1 air nozzles):

2) A cooling time of 9.5 hr, air delivery by the SIOT-7 fan unit, water delivered by two RP-1 nozzles at 90 liter/min per chamber;

3) Cooling time of 9 hr, air delivered by the VO-25s fan unit at 90,000 m^3/hr, water delivered by the RP-1 nozzles: to the gas regenerator by three nozzles at 135 liter/min; to the air regenerator by four nozzles at 180 liters per min.

All reversing devices were set in the center to assure a uniform cooling of the checkers by the natural thrust.

On the right (control) side of the furnace we started dismantling the checkers according to the usual schedule—1-2 hours after opening the end walls of the regenerators. The SIOT-7 fan units delivered air through the end openings to both regenerators. The checkers were hosed down during dismantling.

On the left (experimental) side of the furnace air and water were delivered through the open ends to both regenerators continuously for 6-9.5 hr before the start of dismantling. The results of the observations showed a good effectiveness of preliminary intense cooling of the checkers. Dismantling of the checkers in the regenerators on the right side of the furnace began under a greater intensity of heat radiation than on the left side (Table 1).

The air temperature was also lower in the left, precooled regenerators. The air temperature for the first 8 hours of dismantling the checkers is shown in Table 1.

As a result of reducing the intensity of heat radiation and lowering the air temperature in the regenerators, the continuous work periods of the brickers in the regenerators on the left side were longer than in those on the right side of the furnace. For example, in furnace A (May 1960) during the first eight hours of work the periods were, min:

	Left side	Right side
Gas regenerator	17-68	5-23
Air regenerator	11-23	5-21

Due to this, the useful time and work periods of the brickers working in the regenerators on the left side of the furnace were greater.

TABLE 1. Intensity of Heat Radiation and Air Temperature in Regenerators

No. of furnace	Surface radiating heat	Left (experimental) side of furnace		Right side of furnace	
		gas chamber	air chamber	gas chamber	air chamber
Intensity of thermal radiation, cal/ cm^2· min					
Furnace A	roof	2	2	10	20
(May 1960)	checkers	0	0	–	5–6
Furnace B	roof	2.5	2	19	12
(Aug. 1960)	checkers	0.25	0.5	9	4–7
Air temperature,°C					
Furnace A	–	30–31	35	33–55	57–72
Furnace B	–	24–47	25–35	38–60	33–43

A significant indication of the improved "weather" conditions in the regenerators of the left side of the furnace is the fact that there is no need for an additional watering of the checkers under consideration. The checkers on the right side were watered almost before each entrance of the brickers into the regenerators, and in spite of this the periods of continuous work in these regenerators were shorter.

Preliminary water-air cooling also proved to be beneficial for lowering the dust content of the air in the regenerators. For example, in furnace A (May) when dismantling the checkers in the left air regenerator, 16 and 60 mg of dust were found per cubic meter, and in the right regenerator considerably more.

Preliminary water-air cooling and additional watering of the checkers with sprayers along with the improved weather conditions also make it possible to lower the dustiness in the regenerators when dismantling the checkers. For this purpose it was to our advantage to check the device used at the Magnitogorsk Metallurgical Combine for washing the checkers (a water flow rate of 200-250 liter/min) during between-repair times in order to improve the operation of the open-hearth furnace. It is also necessary to note that, thanks to a certain improvement in the working conditions and the increase in labor efficiency, the time lost for pre-cooling the regenerators did not increase the total repair time for the bottom part of the furnace, and on furnace No. 12 replacement of the checkers on the left side of the furnace was completed even somewhat earlier than on the right side.

Increases in the time for pre-cooling the regenerators from 6 to 9 hr, in the volumes of air delivered to one chamber from 30,000 to 90,000 m^3/hr, and in the flow of water from 60 to 135 and 180 liter/min considerably increased the effectiveness of pre-cooling, especially for the initial period of dismantling work (see Table 2). Under the new (furnace D), slightly improved conditions of cooling the intensity of heat radiation was considerably less at the start and during the first 8-10 hr of dismantling the checkers.

Since observations of furnace D were carried out during the summer and of furnace C during the winter, the effectiveness under the new cooling conditions must be considered underestimated. When observations are under equal conditions, i.e., during the same season of the year, the effectiveness should be greater during a prolonged period of pre-cooling the regenerators. It is also possible to increase the effectiveness of pre-cooling the regenerators by increasing the cooling time from 6 to 9.5 hr and the water flow from 60 to 90 liter/min white keeping the volumes of air (30,000 m^3/hr) by the fan units SIOT-7 now at the plant.

Since the time lost for pre-cooling the regenerators does not increase the established time of their repair, and the working conditions of the repairmen are considerably improved and their efficiency increased, preliminary forced air and water cooling of the regenerators should be made obligatory and included in the plan for the organization of repairs of open-hearth furnaces.

Although pre-cooling of the regenerators improved the working conditions when changing the checkers, it is still insufficient.

TABLE 2. Intensity of Heat Radiation in the Regenerators under Different Cooling Conditions, cal/cm^2 · min

Surface radiating heat	Furnace C (Nov. 1959)		Furnace D (Aug. 1960)	
	gas	air	gas	air
Before start of checker dismantling*				
Roof	4.5–6.0	5.5–8.5	2.5	2.0
Checkers	0	0	0.25	0.5
Subsequent measurements while dismantling the checkers				
Roof	6.5–7.0	10.0	2.0–3.0	3.5
Walls	5.5–6.5	5.5–15.0	1.5–3.5	0.5–8.0
Checkers	0.5–2.0	1.0–10.1	0–0.5	0.5–1.0

* Measured in the end opening.

TABLE 3. Working Conditions for the Repair Brigades

Type work	Work periods, min	Rest periods, min
Checker dismantling (first 16 hr)	8–10	16–20
Checker dismantling (following shifts)	10–15	20–30
Bricking of checkers (first 8 hr)	15–20	15–20
Bricking of checkers (following shifts)	20–25	20–25

Since by prolonging the periods of continuous work and increasing the muscular load in pre-cooled regenerators the possible physiological effect is equalized, it is necessary to change from free working conditions to regulated working conditions while keeping the number of brigades and a work schedule with substitutes.

On the basis of the data obtained concerning the change in body temperature and pulse rate, perspiration, and the duration of continuous working periods in the regenerators for warm seasons of the year (outside air temperature of +10° and higher), we recommend the working conditions shown in Table 3 for the repair brigades when changing the checkers in the pre-cooled regenerators of large-capacity open-hearth furnaces. Here the duration of working periods is maximal and the duration of the rest periods minimal.

Under such conditions the brigades of brickers are divided into three teams for dismantling the checkers and two teams for laying the checkers in order to keep the work going.

The conditions we recommend are approximate. They should be checked for acceptability from the physiological point of view. After checking and correcting, regulated working conditions should be introduced into the plan for the organization of repairs of open-hearth furnaces as a mandatory element of labor organization.

A VALUABLE BOOK

V. K. Gruzinov

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In 1957 the Sverdlovsk office of Metallurgizdat published a book by E. I. Tishchenko and A. S. Emel'yanov entitled, "Dismantling and Bricking Blast Furnaces." The book consists of 12 chapters of well-selected material with an appendix of the most important handbook-information from GOST and technical specifications; this unconditionally increases the practical value of this book, which is intended to increase the qualifications of workers and brigadiers who are refractory brick layers.

The authors generalized the efficient methods of organizing work when dismantling and lining blast furnaces and their auxiliary devices. To work out the methods of organization and efficiency in repair and construction work the authors took a blast furnace with a volume of 1386 m^3, which for present-day conditions already requires additional data for furnaces of large volume.

In the beginning of the book are brief reports on production of efficiency of blast furnaces and the degree of lining wear. For the worker occupied with dismantling and laying new brickwork, it is extremely necessary to know the principles of the technological process, the conditions of servicing the refractory bricks of the blast furnace and its auxiliary equipment.

Lining wear by furnace units is unfortunately inadequately illustrated in the book, and few examples with a description of the causes of the most characteristic erosions of the lining are cited; also there are no descriptions of predetermination of wear of the refractory bricking by using radioactive isotopes of cobalt for monitoring the various technological processes, particularly the measurement of the thickness or density of the materials (defectoscopes, thickness gages, and other instruments).

In Chapter 3, where material for bricking is considered, certain indices should have been refined due to the changes of GOST and the technical specifications; this is also true for the additional introduction of new heat-resistant and carbon materials and articles (the walls of the checker chambers and the combustion chambers of the blast stoves are lined with large blocks of heat-resistant concrete, the lower zone of the well of the blast furnaces is lined with graphitized blocks, etc.).

Chapter 4 does not indicate methods to store the refractory materials or methods of package delivery of the refractories to the working sites.

The description of the repair and construction machines (Chapter 6) should have been placed before the organization of preparatory work. In addition, preparatory work should have received greater attention since the success of carrying out the main operations of capital repair depends on a timely and good preparation.

The technology of dismantling the bricking and also of the lining of the blast furnaces (Chapters 5-8) was developed with sufficient thoroughness. However, the material should have supplemented the description of the leading methods for removing furnace scale as a liquid or solid as well as the devices for large-scale mechanization and automation of refractory operations.

Chapter 9, which describes bricking of carbon blocks, should have been supplemented with the new technology for carbon linings of the well and hearth due to the change in lining construction and the adoption of new carbon materials in furnaces with a volume of 1719 m^3 and more.

The comments made above should be taken into account by the authors when re-issuing this very useful book.

AN UNSUCCESSFUL BROCHURE

G. P. Gromakov

At the end of 1959 Mashgiz published a "Booklet on Techniques of Safety for Masons Bricking, Repairing, and Lining Steelmaking Furnaces"; the author was S. L. Nesterenko.

Systematization and propagation of rules for techniques of safety when laying refractory bricks in the construction and repair of steelmaking furnaces is a very important matter, since there is still little literature on this specific branch of operations. However, neither the author of the Booklet nor the workers of the press (reviewer engineer A. V. Dmitriev, editor D. B. Rikberg and chief editor, engineer V. K. Serdyuk) in our opinion coped with this task.

The Booklet includes laying of refractory bricks in cupolas although everyone knows that they have nothing to do with steelmaking furnaces, to which the brochure is devoted (according to its title). A ladle cannot be called a steelmaking furnace. In addition, the author apparently assumes that by including in the Booklet a description of furnace designs and the All-Union State Standards for refractory materials the qualifications of the refractory workers will be elevated. Meanwhile the refractory workers occupied in the construction and repair of industrial furnaces cannot work without knowing the furnace designs and materials used for their bricking. This knowledge they received during on-the-job training, therefore to place this information in the Booklet does not increase their knowledge and only distracts from the main problem—safety techniques.

The author does not separate the rules and recommendations for safety techniques, which are general for all the furnaces considered, therefore the Booklet abounds in repetition of the same material in different places.

The language in which the brochure is written is an example of slovenliness and primitiveness. In addition to such "terms" as "gassed places", "clamber into the uncooled mixer", etc., the Booklet has completely ungrammatical instructions.

For example, on page 27, paragraph 3 is written: "During training it is necessary to familiarize the workers in detail with moving mechanisms and machines, electric motors, and cables." The recommendations are so confusing that it is difficult to determine their meaning. The steel industry extensively uses such moving machines as locomotives, bridge and floor cranes with which the refractory workers cannot possibly become familiar in detail during training. The steel industry does not use moving electric motors or cables.

On the same page, paragraph 5: "Before starting work it is necessary to check the working order of the knife switches for switching the mechanisms to the electrical network, the proper manufacture and reliability of the safety devices which are installed around the moving parts of the mechanisms and machines at unsafe places—over the chutes, wells, pits, etc." Reliable safety devices for moving parts of construction mechanisms and machines must be installed always regardless of where they stand or are located. It is necessary to think that the author wanted to say that in addition to the indicated safety devices it is necessary to check the reliability of safety devices also around the chutes, pits, and wells.

Page 31, paragraph 3: "Removal of the covers and frames of the charging windows, base beams, coffers and other metal structures must be done by the water-main mechanics..." Dismantling of other metal structures of the steelmaking furnaces, the slabs, elements of the frame, of the casing, communications, etc., is done by the assembly workers.

Page 36-37: "At the present time removal of slag from the slag pockets is still mainly done by the explosive method." The explosive method does not remove the slag, it breaks it up.

Page 37, paragraph 4: "...the strength of the attachment and proper manufacture of the safety devices around electric winches and near other moving mechanism and machines..." Safety devices are installed for moving parts of mechanisms (which includes winches) but not around the winches and moving mechanisms themselves.

Page 42, paragraph 3: "A widely used system for constructing the lining is the installation of frames with center pieces and wooden planking over the framework." This sentence shows that the author has no knowledge of the problem being considered. The lining rests on the center pieces which rest on the supporting timbers.

Page 47, paragraph 5: "Persons systematically violating the rules of safety will not be allowed responsible and dangerous work. Upon repeated violation they will be dismissed from their job." This is a classical example of tautology. If workers are dismissed upon repeated violation of safety rules, then systematic violations are precluded.

Page 69, paragraph 4: "Blocks are manufactured by means of metal, separable forms into which is poured the refractory mass in layers of 100-150 mm thickness and also the binding material; after this it is carefully mixed and compactly tamped by air rammers." The preparation of the refractory mixture is done not in forms but in the mixing machines, as is pointed out in the following paragraph.

Page 78, paragraph 7: "The casing of the mixer is made of sheet steel 20-30 mm thick which has been lined inside with a refractory lining." The mixer is first manufactured of sheet steel and afterwards it is lined, and not conversely as the author reports.

Page 83, paragraph 3: "The work of dismantling the main arch (referring to the mixer) must be done so that it collapses together with the overflow nozzle and the charging hopper." The overflow nozzle of the mixer is located below the main arch, therefore these two units of the mixer cannot collapse simultaneously during their dismantling.

The entire Booklet is filled with such text. It is not understandable how the State Scientific and Technical Press for Machine Building Literature (Mashgiz) could issue such a brochure. It is necessary that Mashgiz take measures to preclude the possibility of a repetition of such errors in the future.

Smelting High-Silicon Pig Iron

Yu. A. Popov. Chelyabinsk Book Publishers, 1961, 107 pages.

The book describes the experiment of smelting high-silicon pig irons at the Chelyabinsk Metallurgical Plant. The author examines the theoretical problems of reducing silicon and iron from ores, cites the optimal conditions of blast-furnace smelting during production of foundry pig and blast furnace ferrosilicon. As is known, the Chelyabinsk blast-furnace operators have achieved good indices in the production of these types of products. Therefore, the book of Yu. A. Popov is undoubtedly of interest to workers in blast furnace shops.

The book examines the problems of the formation of bears in blast furnaces and methods to combat them. A special chapter is devoted to the conditions of changing the blast furnace over from smelting one type of pig iron to smelting of another.

The book unconditionally will be quite useful to workers of blast furnaces and design organizations as well as to students of the metallurgical institutes of higher education.

A. G.

Regenerators of Open-Hearth Furnaces

I. P. Bab'yas and A. I. Chernogolov, Metallurgizdat, 1961, 173 pages.

Regenerator checkers are exceptionally important in the heat operation of open-hearth furnaces. The book is devoted to the problems of heat transfer in the regenerators. The authors examine the construction of slag pockets and regenerators.

The book is also of definite practical interest to workers at enterprises of the metallurgical industry since it gives the conditions for servicing and the characteristics of failure of refractory bricking, as well as means to increase heat efficiency of the regenerators.

A method of monitoring the condition of the checkers is described.

The book is well illustrated with photographs and drawings of the monitoring and measuring instruments.

V. V.

Continuous Pickling Lines

V. G. Ledkov. Metallurgizdat, 1961, 158 pages.

The brochure, which is in a form accessible to a wide readership, is devoted to problems of the process of continuous pickling; the products of hot-rolling strip mills is given; the formation and properties of scale on slabs, flats, and sheets are described.

The described continuous pickling line is divided into three sections: delivery, unrolling the reels, and welding the ends of the strips; pickling, washing and drying the strip; oiling, rolling the reels and arranging the reels. The properties, production and storage of sulfuric acid as the main solution for pickling are described; surface defects of pickled strip are noted.

The equipment of the pickling line, the mechanism for delivering the reels, the uncoilers, scale-brakers, shears, straighteners, welding machines, coilers, drying devices, etc. are examined in detail. In addition, methods of pickling alloy and stainless steels are cited and new methods for removing scale from strip are briefly elucidated.

The brochure is intended for workers of sheet rolling shops.

MISSING PAGES ARE INDEX PAGES
WHICH HAVE BEEN PHOTOGRAPHED
AT THE BEGINNING OF THE VOLUME(S)

Soviet Journals Available in Cover-to-Cover Translation

ABBREVIATION	RUSSIAN TITLE	TITLE OF TRANSLATION	PUBLISHER	TRANSLATION BEGAN Vol.	Issue	Year
AÉ	Atomnaya énergiya	Soviet Journal of Atomic Energy	Consultants Bureau	1	1	1956
Akust. zh.	Akusticheskii zhurnal	Soviet Physics – Acoustics	American Institute of Physics	1	1	1955
	Antibiotiki	Antibiotics	Consultants Bureau	4	1	1959
Astr(on). zh(urn).	Astronomicheskii zhurnal	Soviet Astronomy—AJ	American Institute of Physics	34	1	1957
Avto(mat). svarka	Avtomaticheskaya svarka	Automatic Welding	British Welding Research Association (London)		1	1959
	Avtomatika i Telemekhanika	Automation and Remote Control	Instrument Society of America	27	1	1956
	Biofizika	Biophysics	National Institutes of Health*		1	1957
	Biokhimiya	Biochemistry	Consultants Bureau	21	1	1956
Byull. éksp(erim). biol. i med.	Byulleten' éksperimental'noi biologii i meditsiny	Bulletin of Experimental Biology and Medicine	Consultants Bureau	41	1	1959
DAN (SSSR) / Dokl(ady) AN SSSR	Doklady Akademii Nauk SSSR	The translation of this journal is published in sections, as follows:				
	Life Sciences	Doklady Biochemistry Section	American Institute of Biological Sciences	106	1	1956
	Life Sciences	Doklady Biological Sciences Sections (Includes: Anatomy, biophysics, cytology, ecology, embryology, endocrinology, evolutionary morphology, genetics, histology, hydrobiology microbiology, morphology, parasitology, physiology, zoology sections)	American Institute of Biological Sciences	112	1	1957
	Life Sciences	Doklady Botanical Sciences Sections (Includes: Botany, phytopathology, plant anatomy, plant ecology, plant embryology, plant physiology, plant morphology sections)	American Institute of Biological Sciences	112	1	1957
	Chemical Sciences	Proceedings of the Academy of Sciences of the USSR, Section: Chemical Technology	Consultants Bureau	106	1	1956
	Chemical Sciences	Proceedings of the Academy of Sciences of the USSR, Section: Chemistry	Consultants Bureau	106	1	1956
	Chemical Sciences	Proceedings of the Academy of Sciences of the USSR, Section: Physical Chemistry	Consultants Bureau	112	1	1957
	Earth Sciences	Doklady Earth Sciences Sections (Includes: Geochemistry, geology, geophysics, hydrogeology, mineralogy, paleontology, petrography, permafrost sections)	American Geological Institute	124	1	1959
	Earth Sciences	Proceedings of the Academy of Sciences of the USSR, Section: Geochemistry	Consultants Bureau	106-123	1 6	1957-1958
	Earth Sciences	Proceedings of the Academy of Sciences of the USSR, Sections: Geology	Consultants Bureau	106-123	1 6	1957-1958
	Mathematics	Doklady Soviet Mathematics	The American Mathematics Society	131	1	1961
	Physics	Soviet Physics—Doklady (Includes: Aerodynamics, astronomy, crystallography, cybernetics and control theory, electrical engineering, energetics, fluid mechanics, heat engineering, hydraulics, mathematical physics, mechanics, physics, technical physics, theory of elasticity sections)	American Institute of Physics	106	1	1956
	Physics	Proceedings of the Academy of Sciences of the USSR, Applied Physics Sections (does not include mathematical physics or physics sections)	Consultants Bureau	106-117	1	1956-1957
Derevoobrabat. prom-st'.	Derevoobrabatyvayushchaya promyshlennost'	Wood Processing Industry	Timber Development Association (London)		9	1959
	Élecktrosvyaz	Telecommunications	Massachusetts Institute of Technology*		1	1957
Éntom(ol). oboz(renie)	Éntomologicheskoe obozrenie	Entomological Review	American Institute of Biological Sciences	38	1	1959
Farmakol. (i) toksikol(ogiya)	Farmakologiya i toksikologiya	Pharmacology and Toxicology	Consultants Bureau	20	1	1957
FMM	Fizika metallov i metallovedenie	Physics of Metals and Metallography	Acta Metallurgica*	5	1	1957
Fiziol. zhurn. SSSR (im. Sechenova)	Fiziologicheskii zhurnal im. I. M. Sechenova	Sechenov Physiological Journal USSR	National Institutes of Health*		1	1957
Fiziol(ogiya) rast.	Fiziologiya rastenii	Plant Physiology	American Institute of Biological Sciences	4	1	1957
	Geokhimiya	Geochemistry	The Geochemical Society		1	1958
FTT	Fizika tverdogo tela	Soviet Physics—Solid State	American Institute of Physics	1	1	1959
Izmerit. tekh(nika)	Izmeritel'naya tekhnika	Measurement Techniques	Instrument Society of America		1	1959
Izv. AN SSSR, O(td). Kh(im). N(auk)	Izvestiya Akademii Nauk SSSR: Otdelenie khimicheskikh nauk	Bulletin of the Academy of Sciences of the USSR: Division of Chemical Sciences	Consultants Bureau		1	1952

continued

Izv. AN SSSR, O(td). T(ekhn). N(auk): Met(all). i top.	(see Met. i top.)					
Izv. AN SSSR Ser. fiz(ich).	Izvestiya Akademii Nauk SSSR: Seriya fizicheskaya	Bulletin of the Academy of Sciences of the USSR: Physical Series	Columbia Technical Translations		1	1954
Izv. AN SSSR Ser. geofiz.	Izvestiya Akademii Nauk SSSR: Seriya geofizicheskaya	Bulletin (Izvestiya) of the Academy of Sciences USSR: Geophysics Series	American Geophysical Union		1	1954
Izv. AN SSSR Ser. geol.	Izvestiya Akademii Nauk SSSR: Seriya geologicheskaya	Izvestiya of the Academy of Sciences of the USSR: Geologic Series	American Geological Institute		1	1958
Kauch. i rez.	Kauchuk i rezina	Soviet Rubber Technology	Research Association of British Rubber Manufacturers	18	1	1959
	Kinetika i kataliz	Kinetics and Catalysis	Consultants Bureau	1	3	1960
	Koks i khimiya	Coke and Chemistry USSR	Coal Tar Research Association (Leeds, England)		1	1958
Kolloidn. zh(urn).	Kolloidnyi zhurnal	Colloid Journal	Consultants Bureau	14	1	1952
	Kristallografiya	Soviet Physics – Crystallography	American Institute of Physics	2	1	1957
Metalov. i term. obrabot. metal.	Metallovedenie i termicheskaya obrabotka metallov	Metal Science and Heat Treatment of Metals	Acta Metallurgica	6	1	1958
	Metallurg	Metallurgist	Acta Metallurgica		1	1957
Met. i top.	Metallurgiya i topliva	Russian Metallurgy and Fuels	Eagle Technical Publications		1	1960
Mikrobiol.	Mikrobiologiya	Microbiology	American Institute of Biological Sciences	26	1	1957
OS	Optika i spektroskopiya	Optics and Spectroscopy	American Institute of Physics		6	1959
	Pochvovedenie	Soviet Soil Science	American Institute of Biological Sciences		1	1958
	Priborostroenie	Instrument Construction	British Scientific Instrument Research Association		1	1959
Pribory i tekhn. éks(perimenta)	Pribory i tekhnika éksperimenta	Instruments and Experimental Techniques	Instrument Society of America		1	1957
Prikl. matem. i mekh.	Prikladnaya matematika i mekhanika	Applied Mathematics and Mechanics	American Society of Mechanical Engineers		1	1958
PTÉ	(see Pribory i tekhn. éks.)					
	Problemy Severa	Problems of the North	National Research Council of Canada			
Radiotekh.	Radiotekhnika	Radio Engineering	Massachusetts Institute of Technology*	12	1	1957
Radiotekh. i élektronika	Radiotekhnika i élektronika	Radio Engineering and Electronics	Massachusetts Institute of Technology*	2	1	1957
	Stanki i instrument	Machines and Tooling	Production Engineering Research Assoc.		1	1959
	Stal'	Stal (in English)	Iron and Steel Institute		1	1959
Stek. i keram.	Steklo i keramika	Glass and Ceramics	Consultants Bureau	13	1	1956
Svaroch. proiz-vo	Svarochnoe proizvodstvo	Welding Production	British Welding Research Association		4	1959
Teor. veroyat. i prim.	Teoriya veroyatnostei i ee primenenie	Theory of Probability and Its Applications	Society for Industrial and Applied Mathematics		1	1956
Tsvet. Metally	Tsvetnye metally	Nonferrous Metals	Primary Sources		1	1960
UFN	Uspekhi fizicheskikh Nauk	Soviet Physics – Uspekhi (partial translation)	American Institute of Physics	66	1	1958
UKh	Uspekhi khimii	Russian Chemical Reviews	The Chemical Society (London)		1	1960
UMN	Uspekhi matematicheskikh nauk	Russian Mathematical Surveys	London Mathematical Society	15	1	1960
Usp. fiz. nauk	(see UFN)					
Usp. khim(ii)	(see UKh)					
Usp. matem. nauk	(see UMN)					
Usp. sovr. biol.	Uspekhi sovremennoi biologii	Russian Review of Biology	Oliver and Boyd		48	1959
Vest. mashinostroeniya	Vestnik mashinostroeniya	Russian Engineering Journal	Production Engineering Research Assoc.		4	1959
Vop. gem. i per. krovi	Voprosy gematologii i perelivaniya krovi	Problems of Hematology and Blood Transfusion	National Institutes of Health*		1	1957
Vop. onk.	Voprosy onkologii	Problems of Oncology	National Institutes of Health*		1	1957
Vop. virusol.	Voprosy virusologii	Problems of Virology	National Institutes of Health*		1	1957
Zav(odsk). lab(oratoriya)	Zavodskaya laboratoriya	Industrial Laboratory	Instrument Society of America	25	1	1959
ZhAKh Zh. anal(it). khimii	Zhurnal analiticheskoi khimii	Journal of Analytical Chemistry USSR	Consultants Bureau	7	1	1952
ZhETF / Zh. éksperim. i teor. fiz.	Zhurnal éksperimental'noi i theoreticheskoi fiziki	Soviet Physics—JETP	American Institute of Physics	28	1	1955
ZhFKh Zh. fiz. khimii	Zhurnal fizicheskoi khimii	Russian Journal of Physical Chemistry	The Chemical Society (London)		7	1959
ZhMÉI Zh(urn). mikrobiol. épidemiol. i immunobiol.	Zhurnal mikrobiologii, épidemiologii i immunobiologii	Journal of Microbiology, Epidemiology and Immunobiology	National Institutes of Health*		1	1957
ZhNKh / Zh(urn). neorgan(ich). khim(ii)	Zhurnal neorganicheskoi khimii	The Russian Journal of Inorganic Chemistry	The Chemical Society (London)		1	1959
ZhOKh / Zh(urn). obshch(ei) khimii	Zhurnal obshchei khimii	Journal of General Chemistry USSR	Consultants Bureau	19	1	1949
ZhPKh / Zh(urn). prikl. khimii	Zhurnal prikladnoi khimii	Journal of Applied Chemistry USSR	Consultants Bureau	23	1	1950
ZhSKh / Zh(urn). strukt. khimii	Zhurnal strukturnoi khimii	Journal of Structural Chemistry	Consultants Bureau	1	1	1960
ZhTF / Zh(urn). tekhn. fiz.	Zhurnal teknicheskoi fiziki	Soviet Physics—Technical Physics	American Institute of Physics	26	1	1956
Zh(urn). vyssh. nervn. deyat. (im. Pavlova)	Zhurnal vysshei nervnoi deyatel'nosti (im. I. P. Pavlova)	Pavlov Journal of Higher Nervous Activity	National Institutes of Health*		1	1958

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SIGNIFICANCE OF ABBREVIATIONS MOST FREQUENTLY ENCOUNTERED IN SOVIET PERIODICALS

FIAN	Phys. Inst. Acad. Sci. USSR.
GDI	Water Power Inst.
GITI	State Sci.-Tech. Press
GITTL	State Tech. and Theor. Lit. Press
GONTI	State United Sci.-Tech. Press
Gosénergoizdat	State Power Engr. Press
Goskhimizdat	State Chem. Press
GOST	All-Union State Standard
GTTI	State Tech. and Theor. Lit. Press
IL	Foreign Lit. Press
ISN (Izd. Sov. Nauk)	Soviet Science Press
Izd. AN SSSR	Acad. Sci. USSR Press
Izd. MGU	Moscow State Univ. Press
LÉIIZhT	Leningrad Power Inst. of Railroad Engineering
LÉT	Leningrad Elec. Engr. School
LÉTI	Leningrad Electrotechnical Inst.
LÉTIIZhT	Leningrad Electrical Engineering Research Inst. of Railroad Engr.
Mashgiz	State Sci.-Tech. Press for Machine Construction Lit.
MÉP	Ministry of Electrotechnical Industry
MÉS	Ministry of Electrical Power Plants
MÉSÉP	Ministry of Electrical Power Plants and the Electrical Industry
MGU	Moscow State Univ.
MKhTi	Moscow Inst. Chem. Tech.
MOPI	Moscow Regional Pedagogical Inst.
MSP	Ministry of Industrial Construction
NIIZVUKSZAPIOI	Scientific Research Inst. of Sound Recording
NIKFI	Sci. Inst. of Modern Motion Picture Photography
ONTI	United Sci.-Tech. Press
OTI	Division of Technical Information
OTN	Div. Tech. Sci.
Stroiizdat	Construction Press
TOÉ	Association of Power Engineers
TsKTI	Central Research Inst. for Boilers and Turbines
TsNIÉL	Central Scientific Research Elec. Engr. Lab.
TsNIÉL-MÉS	Central Scientific Research Elec. Engr. Lab.-Ministry of Electric Power Plants
TsVTI	Central Office of Economic Information
UF	Ural Branch
VIÉSKh	All-Union Inst. of Rural Elec. Power Stations
VNIIM	All-Union Scientific Research Inst. of Meteorology
VNIIZhDT	All-Union Scientific Research Inst. of Railroad Engineering
VTI	All-Union Thermotech. Inst.
VZÉI	All-Union Power Correspondence Inst.

Note: Abbreviations not on this list and not explained in the translation have been transliterated, no further information about their significance being available to us - Publisher.